PISCATAQUA RIVER BASIN

NOTTINGHAM , NEW HAMPSHIRE

DROWN'S DAM
NH 00136

STATE NO 184.04

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

JULY 1978

UNCLASSIFIED

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Piscataqua River Basin
Nottingham, New Hampshire
Tributary of Bean River

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The dam is 18 ft. high and 235 ft. long. It is an earthen embankment contained between two vertical dry masonry (stone) walls. The dam is in fair condition. The impounding system has an inadequate spillway discharge capacity. The test flood would overtop the lowest point of the crest by 1.7 ft.

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NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

Identification No.:	NH00136
Name of Dam:	Drown's Dam
Town:	Nottingham
County and State:	Rockingham County, New Hampshire
Stream:	Tributary of Bean River
Date of Inspection:	30 May 1978

BRIEF ASSESSMENT

Drown's Dam is 18 feet high, averages 24 feet in width, and is 235 feet long. It is an earthen embankment contained between two vertical dry masonry (stone) walls. A concrete facing was placed on the upstream face in three different years: 1946, 1964, and 1972. The dam has four sections of spillway, two uncontrolled sections, 21 feet long, placed on either side of a 4-foot wide stoplog spillway, and a 50-foot wide emergency, grass-covered spillway in the left (west) abutment. Drown's Dam, Dolloff Dam, and Gove Dike impound Pawtuckaway Pond. The pond is used now for recreational purposes, is 3 miles long, and has a surface area of about 900 acres. Maximum storage is 11,700 acre-feet.

The dam, at least 136 years old, is in fair condition. The impounding system has an inadequate spillway discharge capacity. Seepage at the downstream toe and leakage through a plugged penstock have a discharge of about 1 cfs.

The spillway capacity at maximum pool is 970 cfs or about 9 percent of the test flood discharge. The test flood would overtop the lowest point of the crest by 1.7 feet.

The owner, New Hampshire Water Resources Board (NHWRB), should, within two years, implement the results, after evaluation of the following: evaluate further all factors relating to overtopping and to the inadequacy of the spillways of the impoundment system, and design or specify remedial measures for the seepages and leakage. Within one year, the NHWRB should implement the following operation and maintenance measures: monitor seepages weekly, repair concrete cracks and spalls, clear brush, trees, and debris from the downstream channel, and establish a surveillance and warning program to be exercised during floods.

Warren A. Guinan
Project Manager
N.H. P.E. No. 2339

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers (OCE), Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

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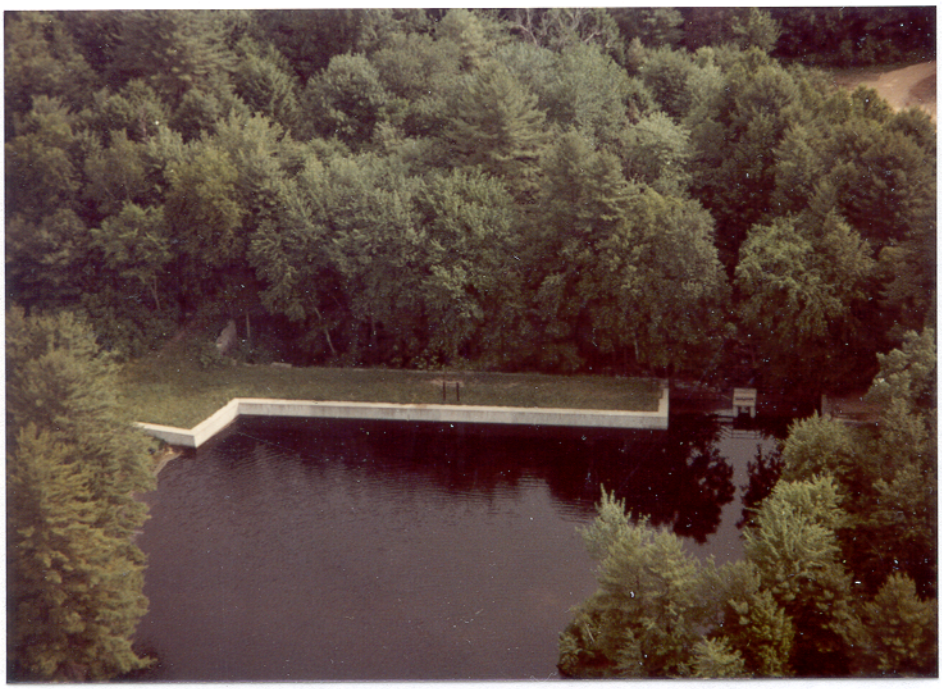
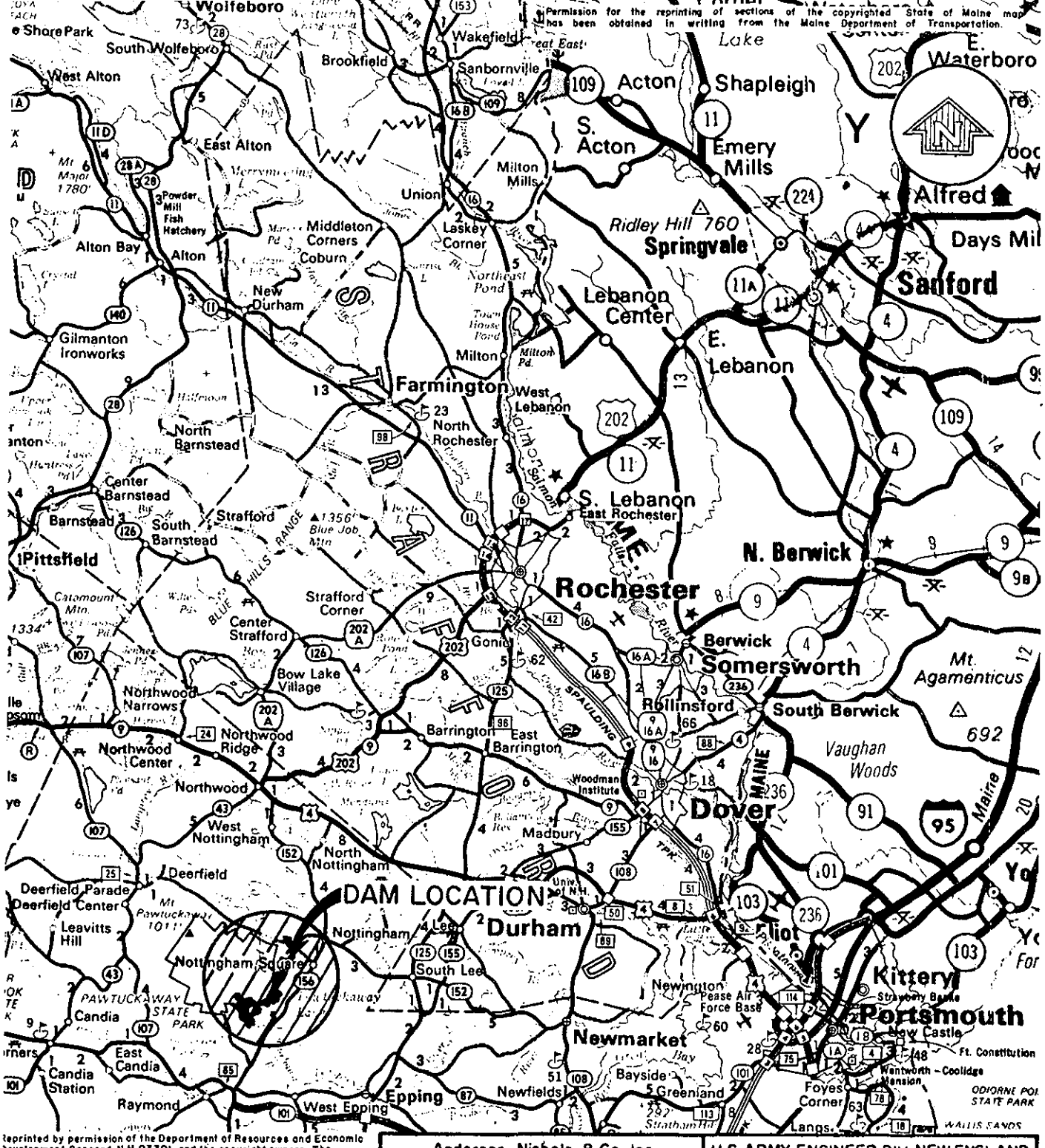


Figure 1 - Overview of upstream face of Drown's Dam.



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SCALE IN MILES

5 0 5

MAP BASED ON STATE OF NEW HAMPSHIRE-STATE OF MAINE OFFICIAL HIGHWAY MAPS.

Anderson-Nichols & Co., Inc. CONCORD NEW HAMPSHIRE	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

DROWN'S DAM
LOCATION MAP

PAWTUCKAWAY POND NEW HAMPSHIRE

			SCALE: 1" = 5Mi
			DATE: JULY 1978

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
DROWN'S DAM

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Anderson-Nichols & Company, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed were issued to Anderson-Nichols & Company, Inc. under a letter of May 3, 1978 from Ralph T. Garver, Colonel, Corps of Engineers. Contract No. DACW33-78-C-0329 has been assigned by the Corps of Engineers for this work.

b. Purpose.

(1) To perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) To encourage and prepare the states to initiate quickly effective dam safety programs for non-Federal dams.

(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location. Drown's Dam is located in the Town of Nottingham, New Hampshire. The dam spans an unnamed tributary approximately 1.6 miles upstream of its confluence with the Bean River. The Bean River then flows another 0.5 mile to its confluence with the North River. The North River continues for another 8 miles to its confluence with the Lamprey River, a major tributary in the Piscataqua River Basin. Drown's Dam, together with Dolloff Dam on the Pawtuckaway River and Gove Dike, form the structural barrier system that impounds Pawtuckway Pond. Drown's Dam is shown on the U.S.G.S. Quadrangle, Mt. Pawtuckaway, New Hampshire, with coordinates approximately at N 43° 06' 30", W 71° 07' 34", Rockingham County, New Hampshire. (See Location Map page iv.)

b. Description of Dam and Appurtenances. Drown's Dam is an earthen embankment contained between two vertical dry masonry walls. The upstream wall has a concrete facing that has been placed in three different years: 1946, 1964, and 1972. The dam is about 235 feet long, 18 feet high, and with a 24-foot topwidth. The dam contains four sections of spillway: (1) two sections of ungated, concrete overflow spillway totaling 42 feet on the east side that is adjacent to the right abutment (facing downstream), (2) a 4-foot wide section of stoplog controlled spillway that is centered between the overflow spillway sections with the stoplog-notch invert about 9 feet below the overflow spillway crest, and (3) a section of uncontrolled vegetated emergency spillway over the left abutment about 50 feet in length. (See plans and sketches in Appendix B.)

Two low dikes have been built: one about 75 feet long situated 250 feet west of the dam and one about 85 feet long situated 150 feet east of the dam. Their crest elevations are about one-half foot above the low point in the emergency spillway. They effectively cut off outflow around the ends of the dam.

c. Size Classification. Intermediate (Hydraulic height - 18 feet, Storage - 11,700 acre-feet) based on storage ($\geq$1,000 to $<$50,000 acre-feet) as given in OCE Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification. Significant hazard. A major breach of the dam would result in the loss of less than 10 lives and appreciable property damage.

e. Ownership. The present structure, along with Dolloff Dam and Gove Dike, are reported to have been built sometime between the years 1839 and 1842 by the Newmarket Manufacturing Company for the purpose of impounding Pawtuckaway Pond for use in their milling operations. Ownership passed on to the Lamprey River Improvement Company, a subsidiary of New Hampshire Gas and Electric Company, sometime prior to 1917. The New Hampshire Water Resources Board (NHWRB) purchased the three structures for one dollar in 1955 from the New Hampshire Gas and Electric Company.

f. Operator. Mr. Vernon K. Knowlton, Chief Engineer, New Hampshire Water Resources Board, 37 Pleasant Street, Concord, New Hampshire 03301, is responsible for the operation of the dams on Pawtuckway Pond. Phone (603) 271-3406.

g. Purpose of Dam. The dike and dams impounding Pawtuckaway Pond were originally constructed to provide greater industrial storage for the Newmarket Manufacturing Company located in Newmarket, New Hampshire. Under the ownership of the Lamprey River Improvement Company, Pawtuckaway Pond was utilized primarily as upstream storage for generation of hydroelectricity for the region, with some recreational usage. Pawtuckaway Pond is presently being used for recreational purposes only.

h. Design and Construction History. Little information was disclosed concerning the original design and construction of the dam. It is believed that the structure is basically an earth-fill dam faced with vertical dry masonry walls.

In October of 1939, the original wooden spillway was replaced by a concrete weir. The upstream side near the western abutment of the dam was refaced with concrete in 1946. The concrete spillway built in 1939 was lowered to its present elevation in 1956.

Drown's Dam was rehabilitated in 1963 and 1964. Work included concrete refacing of the upstream wall, reconstruction of the spillway with the addition of the stoplog section, and fabrication of the steel walkway over the spillway. A portion of the upstream wall was faced with concrete in 1972.

i. Normal Operational Procedures. Pawtuckaway Pond is controlled by discharge through Dolloff and Drown's Dam. Normal pool elevation is 250 feet ± MSL. Usually, pond level is maintained through manipulation of the stoplog level at Dolloff Dam, with all the stoplogs in position at Drown's Dam. No formal operation and maintenance procedures were disclosed; however, the dams are visited on a weekly basis by the NHWRB.

1.3 Pertinent Data

a. Drainage Area. The drainage area consists of 20.66 square miles (13,225 acres) of predominantly wooded terrain.

b. Discharge at Damsite.

(1) Outlet works (conduits) - none

(2) Maximum known flood at damsite is unknown.

(3) Ungated spillway capacity at maximum pool elevation- 520 cfs @ elev. 252.7' MSL*

*Maximum pool elevation based on Dolloff Dam.

(4) Stoplog spillway capacity at recreational pool elevation (250 MSL) is estimated to be 300 cfs assuming removal of all stoplogs.

(5) Stoplog capacity at maximum pool elevation -

450 cfs @ elev. 252.7' MSL*

(6) Total spillway capacity at maximum pool elevation -

970 cfs @ elev. 252.7' MSL*

c. Elevation. (ft. above MSL based on elevation of 250 shown on U.S.G.S. Quadrangle sheet and assumed to be spillway elevation at Dolloff Dam, Pawtuckaway Pond - see Dolloff Dam Inspection Report).

(1) Top of Dam - 254.9

(2) Maximum pool - design surcharge - unknown

(3) Full flood control pool - not applicable

(4) Recreation pool - 250

(5) Spillway crest (gated) - 241 (assuming all stoplogs removed)

(6) Upstream portal invert diversion tunnel - none

(7) Streambed at centerline of dam - 240 - Downstream at toe of stoplog spillway as measured at time of inspection.

(8) Maximum tailwater - unknown

d. Reservoir (miles)

(1) Length of maximum pool - 3

(2) Length of recreation pool - 3

(3) Length of flood control pool - not applicable

e. Storage (acre-feet)

(1) Recreation pool - 11,500

(2) Flood control pool - not applicable

(3) Design surcharge - unknown

(4) Top of dam - 11,700 (storage based on Dolloff Dam)

*Maximum pool elevation based on Dolloff Dam.

f. Reservoir Surface (acres)

(1) Top of dam - 1125

(2) Maximum pool - 985

(3) Flood control pool - not applicable

(4) Recreation pool - 903

(5) Spillway crest - 422

g. Dam

(1) Type - Earthen embankment between vertical dry masonry walls, upstream wall is concrete faced.

(2) Length - 235'

(3) Height - 18' (structural height)

(4) Top Width - 24'

(5) Side Slopes - Vertical

(6) Zoning - unknown

(7) Impervious core - unknown

(8) Cutoff - unknown

(9) Grout curtain - unknown (foundation and spot grouting done in past)

h. Diversion and Regulating Tunnel - not applicable

i. Spillway

(1) Type - ungated and stoplog

(2) Length of weir - 42' (ungated); 4' (stoplog)

(3) Crest elevation - 250' MSL* (ungated); 241 ' MSL (all stoplogs removed)

(4) Gates - none

(5) U/S Channel - Pawtuckaway Pond

(6) D/S Channel - about 50 feet wide, immediately

*Based on elevation shown on U.S.G.S. Quadrangle sheet and assumed to be spillway elevation.

downstream appears to be bedrock, further downstream bottom covered by silt, sand, gravel, cobbles, and boulders; brush and trees overhang channel with fallen logs in channel.

(7) General - four-foot wide steel grate access bridge over spillway.

j. Regulating Outlets - The stoplog section is centered between the ungated spillways. It consists of a 6-inch slab with 4-inch stoplog guides. The stoplogs are 4" x 8" timbers, four feet long. The stoplog slot is covered by a 9-inch concrete slab at the same elevation as the iron-decked bridge over the ungated spillway section.

SECTION 2
ENGINEERING DATA

2.1 Design

No original design data were disclosed for Drown's Dam.

2.2 Construction

A report prepared by H.F. Dunham for the Lamprey River Improvement Company, dated December 5, 1918 was the earliest investigation found. Dunham's report contains a sketch of a cross section copied from a report by W.M. Oliver, C.E., to Newmarket Manufacturing Co., dated 1889. (See Appendix B.) The visual inspection is generally consistent with the 1889 sketch for the exposed portions of the dam, except as modified by the addition of the concrete facing and spillways.

2.3 Operation

No engineering operational data were disclosed.

2.4 Evaluation

a. Availability. Very little engineering data were available for Drown's Dam. A search of files of the NHWRB disclosed only a limited amount of recorded information.

b. Adequacy. Because of the limited amount of detailed data available the final assessments and recommendations of this investigation are based on visual inspection and hydrologic and hydraulic calculations.

c. Validity. The visual inspection is generally consistent with the 1889 sketch for the exposed portions of the dam. The plans found for the NHWRB rehabilitation are in general conformity with the structure as seen in the visual inspection. (For details, see Section 3 & 6 and Appendix B.)

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. Drown's Dam is one of three major structures (the others being Dolloff Dam and Gove Dike) on Pawtuckaway Pond. The pond level is controlled by both Drown's Dam and Dolloff Dam; Gove Dike has no control or outlet structure.

The watershed above the pond is heavily wooded. Numerous cottages and homes have been built on the southeast portion of the perimeter of the pond.

b. Dam. The dam consists of an earthen embankment, with a vertical dry masonry wall on the downstream side and a dry masonry wall faced with concrete on the upstream side. (See Appendix C - Figures 2, 3, and 4.) The dam is about 235 feet long, 18 feet high, 24 feet wide at the crest. The crest of the dam is vegetated.

The top of the concrete facing on the upstream side was about 5 feet above pond level at the time of inspection, and the upstream water depth at the dam was about 10 feet. Five vertical hairline cracks were noted in the concrete facing with a maximum width of about 1/10 inch and spaced about 20 feet apart.

At the left end of the dam is a vegetated emergency spillway. (See Appendix C - Figure 5.)

Two tree stumps (6 to 8 inches in diameter) are visible in the face near the top of the downstream dry masonry wall.

No evidence of significant lateral or vertical movement of the dam was observed.

Near the west end of the dam a penstock formerly came out near the bottom of the downstream dry masonry wall. The penstock has been cut off at the face of the wall and the pipe through the dam plugged with stones and concrete. (See Appendix C - Figure 6.)

Seepage of about 1 cfs was observed near the downstream toe at the left end of the dam. A small part of this seepage

comes out of the penstock plug. Most of the seepage, however, appears to be coming through or under the dam. (See Appendix C - Figures 6 and 7.)

c. Appurtenant Structures.

(1) The dikes east and west of the dam are both about 3 feet high, and the water in the reservoir was some distance from both dikes at the time of the inspection. (See Appendix C - Figures 8 and 9.) The crest of both dikes was about 3½ feet above the pond level at the time of the inspection. These two dikes effectively cut off outflow around both ends of the dam.

(2) The spillway consists of two 21-feet long fixed-level concrete overflow sections and a 4-foot wide stoplog section. (See Appendix C - Figure 10.) In general, the concrete is in good condition. Surface erosion of concrete is limited to areas in contact with water and consists primarily of the loss of surface laitance. Two hairline cracks and one area of minor spalling were observed on the downstream face of the buttress walls at the stoplog spillway, just above the level of the concrete overflow-spillway apron. The spalling appears to be due to mechanical damage rather than weathering. The slots for the stoplogs are in good condition, but the stoplogs could not be inspected because water was discharging over the top of the stoplogs.

(3) A four-foot wide steel service bridge, with a steel-grating floor and handrails crosses the spillway. All of the steel shows some evidence of rusting.

d. Reservoir Area. The reservoir slopes are generally covered with trees and brush. (See Appendix C - Figure 11.) A beach is located a short distance upstream from the east abutment. Unauthorized automobiles were parked in the vicinity of the east abutment. Numerous cottages and homes have been built on the southeast portion of the perimeter of the reservoir.

e. Downstream Channel. The channel immediately downstream of the spillway appears to be in bedrock. Some brush overhangs the channel, and trees and brush are growing adjacent to the channel. (See Appendix C - Figure 12.) Three logs, which appear to have come over the spillway, were lying immediately downstream of the spillway; two were in the downstream channel, and one was on the spillway apron. (See Appendix C - Figure 10.) An unpaved access road adjacent to the channel leads up to the east abutment. A few houses have been built adjacent to the stream about

one-half mile downstream of the dam. The Village of Nottingham is located about three miles downstream of the dam on the banks of the North River.

3.2 Evaluation

The observed condition of the dam is fair. The potential problems observed during the visual inspection are:

(a) seepage at the toe of the dam, especially in the vicinity of the plugged opening of the former penstock through the dam,

(b) leakage through the penstock plug itself,

(c) cracks in the concrete upstream facing,

(d) rusting of the service bridge,

(e) cracks in the concrete buttress walls at the stoplog spillway,

(f) brush and trees overhanging the discharge channel downstream of the dam, and

(g) presence of logs in the discharge channel downstream of the spillway.

The two stumps at the top of the downstream masonry wall are not considered problems because they are small and higher than the normal pool elevation.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

No written procedures were disclosed. The level of Pawtuckaway Pond is controlled by a discharge through Dolloff and Drown's Dam. Gove Dike, the third impounding structure, has no outlet facilities. The NHWRB has operated the pond since 1955.

Drown's Dam usually has all its stoplogs in position, allowing for control of the water level through Dolloff Dam. The pond elevation during the recreational season is maintained reasonably constant at 250 feet ± MSL. In the fall, the level is drawn down, allowing abutters to make improvements to their shoreline and providing some storage for spring runoff.

4.2 Maintenance of Dam

Drown's Dam is maintained by the NHWRB.

4.3 Maintenance of Operating Facilities

Throughout the year, the dam is visited by the NHWRB on a weekly basis. During these visits grass and brush are trimmed, and debris, if any, is removed.

4.4 Description of Any Warning Systems in Effect

No written warning system was disclosed for Drown's Dam.

4.5 Evaluation

The operation and maintenance procedures for Drown's Dam, consisting of a weekly program of inspection, should insure that all problems encountered can be remedied within a reasonable period of time. The NHWRB should also establish a warning program to be exercised during floods.

SECTION 5
HYDROLOGY AND HYDRAULIC ANALYSIS

5.1 Evaluation of Features

a. Design Data. No original hydrologic and hydraulic design data (1839-1842) were disclosed for the structures impounding Pawtuckaway Pond. However, hydrologic and hydraulic information dating from the ownership by the Lamprey River Improvement Company to the present ownership by the NHWRB, were found and assessed to determine their acceptability in evaluating the overtopping potential of Drown's Dam.

Drown's Dam is classified as being intermediate in size having a maximum storage capacity of 11,700 acre-feet.

To determine the hazard classification for Drown's Dam, the impact of failure of the dam at maximum pool was assessed using Guidance for Estimating Downstream Dam Failure Hydrographs issued by the Corps of Engineers. The analysis covered the reach extending from the dam to Nottingham Center, a distance of about 3 miles along the North River. Failure of Drown's Dam at maximum pool would probably result in an increase in stage of 7.5 feet along the reach. An increase in water depth of this magnitude would probably result in the loss of less than 10 lives, possibly none, the severance of a town road about 1,000 feet downstream of the dam and a private driveway about 2,500 feet downstream. Innundation of the school playground at Nottingham Center might occur; little other property damage is likely.

As a result of the analysis described above, Drown's Dam was classified - Significant Hazard. Using OCE Recommended Guidelines for Safety Inspection of Dams, the recommended spillway test flood is the Probable Maximum Flood. The test flood discharge for Pawtuckaway Pond, having a drainage area of 20.66 square miles, was determined to be 11,200 cfs.

b. Experience Data. No information regarding past overtopping of the structure was disclosed.

c. Visual Observations. No visual evidence was disclosed that would indicate that the dam has ever been overtopped. Debris may partially obstruct the spillway opening and cause a reduction in the capacity of the spillway during a flood occurrence.

d. Overtopping Potential. Drown's Dam in conjunction with Gove Dike and Dolloff Dam, is unable to pass the test flood (PMF) without overtopping. The spillway capacity of Drown's Dam is only about 9 percent of the test flood discharge. The water depth over the lowest point of the structure was calculated to be 1.7 feet for this flood.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observation.

(1) Embankment. Visual observation indicated two problems relating to structural stability: (a) leakage through the plug at the old penstock opening through the dam, and (b) seepage through and/or under the dam. The hairline cracks in the concrete facing on the upstream wall of the dam are of minor significance in their present condition, but could lead to future problems if they are not repaired.

(2) Appurtenant Structures. The hairline cracks and minor spalling in the buttress walls at the stoplog spillway and the rusting of the service bridge are of minor significance in their present condition, but could lead to future problems if they are not repaired or corrected.

b. Design and Construction Data. A report dated December 5, 1918, shows a cross-section sketch of the dam that was copied from a report prepared in 1889. (See Appendix B.) Present field inspection confirms the visible information of the sketch. No other design and construction data pertinent to the structural stability were disclosed.

c. Operating Records. No operating records pertinent to the structural stability were disclosed.

d. Post-Construction Changes. The original upstream dry masonry wall was faced with concrete in 1946, 1964, and 1972. The present stoplog and overflow spillway was reconstructed in 1964.

e. Seismic Stability. This dam is in Seismic Zone 2 and hence does not have to be evaluated for seismic stability according to the OCE Recommended Guidelines.

7.1 Dam Assessment

a. Condition. The visual inspection indicates that Drown's Dam is in fair condition. The major concerns that may affect the overall long-term integrity of the dam are as follows:

(1) overtopping potential,

(2) seepage at the toe of the dam in the vicinity of the plugged opening of the former penstock, and

(3) leakage through the penstock itself.

Because Drown's Dam is an integral part of the Pawtuckaway Pond impoundment system that includes Gove Dike and Dolloff Dam, its relationship to the test flood requires hydrologic and hydraulic analyses of all three structures. The spillway capacity of the combined system is considered inadequate. (See Dolloff Dam report.)

Assuming that Gove Dike and Dolloff Dam do not fail, Drown's Dam would be overtopped by 1.7 feet under conditions of the test flood. This depth of overtopping takes into consideration the fact that the emergency spillway at Drown's Dam is only slightly higher than the low ground adjacent to the left abutment at Dolloff Dam and about one foot lower than Gove Dike. Drown's Dam, however, has stood the test of time-at least 136 years.

b. Adequacy of Information. The information available is such that the assessment of the condition of the dam must be based on the visual inspection.

c. Urgency. The recommendations enumerated in 7.2 below should be implemented within two years. The operational and maintenance procedures in 7.3 below should be implemented within one year.

d. Necessity for Additional Investigation. The information available from the visual inspection is adequate to identify the potential problems of overtopping, seepage, and leakage through the penstock plug. These problems require the attention of a competent engineer to design or specify remedial measures to rectify the problems; if left

unattended, they could lead to instability of the structure.

7.2 Recommendations

It is recommended that NHWRB should accomplish the remedial measures resulting from the following:

a. Evaluate further the potential for overtopping and the inadequacy of the spillway for the total impoundment system of Pawtuckaway Pond.

b. Design the remedial measures needed to eliminate or control the seepage at the downstream toe and the leakage through the penstock.

c. Specify the repairs to seal the cracks in the concrete facings.

7.3 Remedial Measures

a. Alternatives. The NHWRB should consider as an alternative pending implementation and results of the recommendations above that the reservoir be operated at a lower level during the year so as to provide more storage for extreme flood events.

b. Operation and Maintenance Procedures.

(1) Monitor seepage and leakage at the dam on a weekly basis.

(2) Remove the existing debris in the spillway, apron, and immediate downstream channel and clear the brush and trees about 50 feet downstream of the dam.

(3) Repair the cracks and spalling in the concrete buttress walls of the stoplog spillway and provide a corrosion-resistant coating on the service bridge.

(4) Establish a surveillance and warning program to follow in the event of floodflow conditions or imminent dam failure. The warning system should be included also in the written procedures of "Project Linkup", a disaster plan involving Civil Defense (as coordinator) state agencies, and town officials. "Project Linkup", at this time, is in draft form awaiting the Governor's approval.

APPENDIX A

CHECK LIST - VISUAL INSPECTION

VISUAL INSPECTION CHECKLIST

PARTY ORGANIZATION

PROJECT Drown's Dam, New Hampshire

DATE May 30, 1978

TIME 9:45 A.M.

WEATHER Sunny, hot

W.S. ELEV. 250.1 U.S. 240 DN.S.

PARTY:

1. Warren Guinan
2. Robert Langen
3. Stephen Gilman
4. Ronald Hirschfeld
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Hydraulic/Hydrologic	R.C. Langen	
2.	Structural Stability	S. Gilman	
3.	Soils and Geology	R. Hirschfeld	
4.			
5.			
6.			
7.			
8.			
9.			
10.			

PERIODIC INSPECTION CHECK LIST

PROJECT Drown's Dam, New Hampshire DATE May 30, 1978

PROJECT FEATURE Main Dam Embankment NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT	
Crest Elevation	255 MSL
Current Pool Elevation	Gage reading 25.1 (250.1 MSL) (assumed)
Maximum Impoundment to Date	Unknown
Surface Cracks	None visible; crest if grass-cover
Pavement Condition	Not paved
Movement or Settlement of Crest	None at concrete wall on upstream side. Apparent uneven settlement of dry masonry wall on downstream side.
Lateral Movement	None
Vertical Alignment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Good
Indications of Movement of Structural Items on Slopes	None
Trespassing on Slopes	None
Sloughing or Erosion of Slopes or Abutments	None
Rock Slope Protection - Riprap Failures	N.A.
Unusual Movement or Cracking at or near Toes	None
Unusual Embankment or Downstream Seepage	Seepage of 1 to 2 cfs at downstrea toe near west end of dam
Piping or Boils	None
Foundation Drainage Features	None known
Toe Drains	None known
Instrumentation System	None known

PERIODIC INSPECTION CHECK LIST

PROJECT Drown's Dam, New Hampshire DATE May 30, 1978

PROJECT FEATURE West Dike NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	
Crest Elevation	253.5 MSL
Current Pool Elevation	250.1 MSL (assumed)
Maximum Impoundment to Date	Unknown
Surface Cracks	None
Pavement Condition	Not paved
Movement or Settlement of Crest	None
Lateral Movement	None
Vertical Alignment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Good
Indications of Movement of Structural Items on Slopes	None
Trespassing on Slopes	None
Sloughing or Erosion of Slopes or Abutments	None
Rock Slope Protection - Riprap Failures	Riprap on downstream slope
Unusual Movement or Cracking at or near Toes	None
Unusual Embankment or Downstream Seepage	None-no water against upstream side of dike
Piping or Boils	None-no water against upstream side of dike
Foundation Drainage Features	None
Toe Drains	None
Instrumentation System	

PERIODIC INSPECTION CHECK LIST

PROJECT Drown's Dam, New Hampshire DATE May 30, 1978

PROJECT FEATURE East Dike NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	
Crest Elevation	253.1 MSL
Current Pool Elevation	250.1 MSL
Maximum Impoundment to Date	Unknown
Surface Cracks	None
Pavement Condition	Not paved
Movement or Settlement of Crest	None
Lateral Movement	None
Vertical Alignment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Good
Indications of Movement of Structural Items on Slopes	None
Trespassing on Slopes	None
Sloughing or Erosion of Slopes or Abutments	None
Rock Slope Protection - Riprap Failures	Riprap on upstream face
Unusual Movement or Cracking at or near Toes	None
Unusual Embankment or Downstream Seepage	None-no water against upstream side of dike
Piping or Boils	None-no water against upstream side of dike
Foundation Drainage Features	None
Toe Drains	NOne
Instrumentation System	

PERIODIC INSPECTION CHECK LIST

PROJECT Drown's Dam, New Hampshire DATE May 30, 1978

PROJECT FEATURE Control Tower NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	
a. Concrete and Structural	
General Condition	Good
Condition of Joints	Good
Spalling	One 6" x 6" mechanical spall
Visible Reinforcing	None
Rusting or Staining of Concrete	Little one, 8" x 16" area on right spillway sidewall
Any Seepage or Efflorescence	None visible
Joint Alignment	Good
Unusual Seepage or Leaks in Gate Chamber	None visible
Cracks	Two hairline cracks
Rusting or Corrosion of Steel	None visible
b. Mechanical and Electrical	None
Air Vents	
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	
Emergency Gates	
Lightning Protection System	
Emergency Power System	
Wiring and Lighting System in Gate Chamber	

PERIODIC INSPECTION CHECK LIST

PROJECT Drown's Dam, New Hampshire DATE May 30, 1978

PROJECT FEATURE Stoplog Outlet NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	LOW-LEVEL
a. Approach Channel	N.A. Low-level outlet is incorpor into overflow spillway of dam.
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	
Condition of Concrete	Good
Stop Logs and Slots	Visible portion of slots in good condition. Stoplogs not visible because of overflow.

PERIODIC INSPECTION CHECK LIST

)JECT Drown's Dam, New Hampshire DATE May 30, 1978

)JECT FEATURE Outlet Works NAME

SCIPLINE NAME

AREA EVALUATED	CONDITION
LET WORKS - TRANSITION AND CONDUIT	
eneral Condition of Concrete	Good
ıst or Staining on Concrete	None
palling	None
rosion or Cavitation	None
racking	None
lignment of Monoliths	Good
lignment of Joints	No movement
umbering of Monoliths	

PERIODIC INSPECTION CHECK LIST

PROJECT Drown's Dam, New Hampshire DATE May 30, 1978

PROJECT FEATURE Outlet Works NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete	Good; concrete surfaces rough
Rust or Staining	None
Spalling	None
Erosion or Cavitation	None
Visible Reinforcing	None
Any Seepage or Efflorescence	None
Condition at Joints	None
Drain holes	None
Channel	
Loose Rock or Trees Overhanging Channel	Some brush overhanging channel Some trees adjacent to channel
Condition of Discharge Channel	Some logs in channel. Channel bottom appears to be bedrock immediately downstream of dam. Further downstream, channel bottom consists of sand, gravel, cobbles and boulders.

PERIODIC INSPECTION CHECK LIST

PROJECT Drown's Dam, New Hampshire DATE May 30, 1978

PROJECT FEATURE Service Bridge NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - SERVICE BRIDGE	
a. Super Structure	
Bearings	Channels embedded in concrete
Anchor Bolts	None
Bridge Seat	
Longitudinal Members	Steel channels - rusting
Under Side of Deck	
Secondary Bracing	Not applicable
Deck	Steel grating - rusting, some loss of steel
Drainage System	
Railings	Welded steel-good condition
Expansion Joints	None
Paint	Deteriorating-rust showing thru paint
b. Abutment & Piers	
General Condition of Concrete	Good
Alignment of Abutment	Good
Approach to Bridge	Good
Condition of Seat & Backwall	

PERIODIC INSPECTION CHECK LIST

PROJECT Drown's Dam, New Hampshire DATE May 30, 1978

PROJECT FEATURE Spillway Weir NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	N.A. Spillway weir is incorporated into face of dam near east abutment
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b. Weir and Training Walls	
General Condition of Concrete	Good-Surface erosion limited to los of surface laitance.
Rust or Staining	None visible
Spalling	None visible
Any Visible Reinforcing	None
Any Seepage or Efflorescence	None
Drain Holes	N.A.
c. Discharge Channel	
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	Some brush and trees
Floor of Channel	Appears to be bedrock immediately downstream of the spillway. Furthe downstream channel bottom consists of sand, gravel, cobbles and boulde
Other Obstructions	Some logs in channel

PROJECT Drown's Dam, New Hampshire DATE May 30, 1978

PROJECT FEATURE Reservoir NAME R. Langen

Pawtuckaway Pond

AREA EVALUATED	REMARKS
Stability of Shoreline	Good
Sedimentation	Minor, no visible problems
Changes in Watershed Runoff Potential	Minor
Upstream Hazards	Several homes, most are at least 6' above lake.
Downstream Hazards	Town road about ½ mile downstream. Nearest village is Nottingham Center, about 3 miles downstream.
Alert Facilities	None observed
Hydrometeorological Gages	None observed
Operational & Maintenance Regulations	None posted

APPENDIX B

INSPECTION REPORTS/SKETCHES

DROWN'S DAM

PUBLIC SERVICE COMMISSION OF NEW HAMPSHIRE—DAM RECORD

TOWN	Nottingham	TOWN NO. 4	STATE NO 174.04
RIVER STREAM	Pawtuckaway, Pond Outlet, To North River	DROWN'S DAM	
DRAINAGE AREA	20.66 Sq. Mi.	POND AREA 334.2 Acres	
DAM TYPE	Gravity	FOUNDATION NATURE OF	
MATERIALS OF CONSTRUCTION	Dry Stone, Earth		
PURPOSE OF DAM	POWER—CONSERVATION—DOMESTIC—RECREATION—TRANSPORTION—PUBLIC UTILITY		
HEIGHTS TOP OF DAM TO BED OF STREAM	19'	TOP OF DAM TO SPILLWAY CRESTS 6'	
SPILLWAYS, LENGTHS DEPTHS BELOW TOP OF DAM	50'	LENGTH OF DAM	222'
FLASHBOARDS TYPE, HEIGHT ABOVE CREST	Removable stop planks	(REMOVABLE STOP PLANKS)	
OPERATING HEAD CREST TO N. T. W.		TOP OF FLASHBOARDS TO N. T. W.	
WHEELS, NUMBER KINDS & H. P.			
GENERATORS, NUMBER KINDS & K. W.			
H. P. 90 P. C. TIME 100 P. C. EFF.		H. P. 75 P. C. TIME 100 P. C. EFF.	
REFERENCES, CASES, PLANS, INSPECTIONS, REMARKS			

OWNER- Lamprey River Improvement Company

CONDITION- Good

ETC.- Yes. Will be subject to periodic inspection.

To the Public Service Commission:

The foregoing memorandum on the above dam is submitted covering inspection made August 8, 1935, according to notification to owner dated July 31, 1935, and bill for same is enclosed.

Sept. 18, 1935
Copy to Owner

Samuel J. Lord
Hyd. Eng.

PUBLIC SERVICE COMMISSION OF NEW HAMPSHIRE—DAM RECORD

TOWN	Nottingham	TOWN NO. 4	STATE NO 174.04
RIVER STREAM	Pawtuckaway Pond Outlet, To North River	DROWN'S DAM	
DRAINAGE AREA	20.66 Sq. Mi.	POND AREA 984.2 Acres	
DAM TYPE	Gravity	FOUNDATION NATURE OF	
MATERIALS OF CONSTRUCTION	Dry Stone, Earth		
PURPOSE OF DAM	POWER—CONSERVATION—DOMESTIC—RECREATION—TRANSPORTION—PUBLIC UTILITY		
HEIGHTS TOP OF DAM TO BED OF STREAM	19'	TOP OF DAM TO SPILLWAY CRESTS 6'	
SPILLWAYS, LENGTHS DEPTHS BELOW TOP OF DAM	50'	LENGTH OF DAM	222'
FLASHBOARDS TYPE, HEIGHT ABOVE CREST	Removable stop planks	(REMOVABLE STOP PLANKS)	
OPERATING HEAD CREST TO N. T. W.		TOP OF FLASHBOARDS TO N. T. W.	
WHEELS, NUMBER KINDS & H. P.			
GENERATORS, NUMBER KINDS & K. W.			
H. P. 90 P. C. TIME 100 P. C. EFF.		H. P. 75 P. C. TIME 100 P. C. EFF.	
REFERENCES, CASES, PLANS, INSPECTIONS, REMARKS			

OWNER- Lamprey River Improvement Company

CONDITION- Good

SAFE- Yes. Will be subject to periodic inspection.

To the Public Service Commission:

The foregoing memorandum on the above dam is submitted covering inspection made August 8, 1935, according to notification to owner dated July 31, 1935, and bill for same is enclosed.

Sept. 16, 1935
Copy to Owner

Samuel J. Lord
Hyd. Eng.

PUBLIC SERVICE COMMISSION OF NEW HAMPSHIRE—DAM RECORD I-4563

TOWN	NOTTINGHAM	TOWN NO. 4	STATE NO. ~~38~~ 124
RIVER STREAM	Pawtuckaway Pond Outlet, To North River		DROWN'S DAM
DRAINAGE AREA	20.66 Sq. Mi.	POND AREA	934.2 Acres
DAM TYPE	Gravity	FOUNDATION NATURE OF	
MATERIALS OF CONSTRUCTION	Cut Stone, Earth		
PURPOSE OF DAM	POWER—CONSERVATION—DOMESTIC—RECREATION—TRANSPORTATION—PUBLIC UTILITY		
HEIGHTS, TOP OF DAM TO BED OF STREAM	18'	TOP OF DAM TO SPILLWAY CRESTS	6'
SPILLWAYS, LENGTHS DEPTHS BELOW TOP OF DAM	50'	LENGTH OF DAM	222'
FLASHBOARDS, TYPE, HEIGHT ABOVE CREST	Removable stop planks		
OPERATING HEAD CREST TO N. T. W.		TOP OF FLASHBOARDS TO N. T. W.	
WHEELS, NUMBER KINDS & H. P.			
GENERATORS, NUMBER KINDS & K.W.			
H. P. 90 P. C. TIME 100 P. C. EFF.		H. P. 75 P. C. TIME 100 P. C. EFF.	
REFERENCES, CASES, PLANS, INSPECTIONS, REMARKS			

2151

OWNER Lamprey River Improvement Co. c/o P. H. Burrowes, Supt. Newmarket CONTRACTOR NO.

	RECEIVED	INVESTIGATED BY	DATE
APPLICATION			

IF DAM IMPROPERLY CONSTRUCTED IT Would BE A MENACE TO THE PUBLIC SAFETY

IS DAM SUBJECT TO PROVISIONS OF P. L. CHAP. 218, SECTS 15-26? Yes

	RECEIVED	CHECKED BY	DATE
PLANS & SPECIFICATIONS			
	APPROVED BY COMMISSION	COMMISSION CONSTRUCTION INSPECTOR	

FINAL CONSTRUCTION APPROVAL CHARGES PAID

IS DAM SUBJECT TO PERIODIC INSPECTION? Yes

DAM INSPECTION RECORD

DATE	INSPECTOR	REPORT	CHARGES	PAID	DATE	INSPECTOR	REPORT	CHARGES	PAID
9/6/35	A.C. Blake	9/18/35	10.00	10/14/35					
Condition--Good									

NEW HAMPSHIRE WATER RESOURCES BOARD

INVENTORY OF DAMS AND WATER POWER DEVELOPMENTS

DAM Drown's Dam

BASIN Ocean NO. 4 - 35 - 5-4143
RIVER MILES FROM MOUTH D.A.SQ.MI. 20.66
TOWN Nottingham OWNER Lamprey River Co.
LOCAL NAME OF DAM
BUILT DESCRIPTION Gravity - Cut stone

POND AREA-ACRES 934 A DRAINAGE SQ.MI. POND CAPACITY-ACRE FT.
HEIGHT-TOP TO BED OF STREAM-FT. DAM. MAX. MIN.
OVERALL LENGTH OF DAM-FT. 222 MAX.FLOOD HEIGHT ABOVE CREST-FT.
PERMANENT CREST ELEV.U.S.G.S. LOCAL GAGE
TAILWATER ELEV.U.S.G.S. LOCAL GAGE
SPILLWAY LENGTHS-FT. FREEBOARD-FT. 6
FLASHBOARDS-TYPE, HEIGHT ABOVE CREST

WASTE GATES-NO.	WIDTH MAX. OPENING	DEPTH SILL BELOW CREST

REMARKS Condition Good

POWER DEVELOPMENT

UNITS	NO.	RATED HP	HEAD FEET	C.F.S. FULL GATE	KW	NAME

USE

REMARKS

DATE 26

PAWTUCKAWAY AND MENDUM PONDS

REPORT FROM H. F. DUNHAM

to

D. A. BELDEN, PRESIDENT

LAMPREY RIVER IMPROVEMENT COMPANY

December 5, 1918

H. F. DUNHAM
SINGER BUILDING
149 BROADWAY, NEW YORK
PHONE, 3167 CORTLANDT

M. Am. Soc. C. E.
M. Cleveland Engineering Society
M. American Water Works Association

December 5, 1918.

Mr. D. A. Belden, President,
Lamprey River Improvement Company,
Haverhill, Mass.

Dear Sir:-

Agreeably to your request, I have made a study of conditions pertaining to the two artificial reservoirs owned by your company, known as Pawtuckaway Lake and Mendum Pond, both of which are in the towns of Nottingham and Barrington, New Hampshire. I have kept in view your desire to be informed concerning the type of construction and present condition of the various dams, spillways and controlling apparatus, and particularly as to any defects which should be remedied in the interest of public safety to life and property.

1. The reservoirs are within the drainage area tributary to the Lamprey River ten to fifteen miles westerly from Newmarket, N. H. The area tributary to each reservoir is not definitely known but has been estimated at about six square miles for the Mendum Reservoir and twenty square miles for the Pawtuckaway. More exact determination would have been made but for the fact that the U. S. Geological Survey is now plotting the notes of a quadrangle covering the reservoirs and their drainage districts. Both of the reservoirs are formed by dams built at the outlets of these small lakes and at overflow points where the higher elevation of water would cause a discharge into a depression or ravine at a distant point. There are three dams at Pawtuckaway as attached map shows, known locally as "Dollof

Dam", "Drown's Dam", and the "Gove Dam" indicated on the map respectively as Dams No. 1, 2 and 3. At Mendum's Pond there is but one dam, located at the main outlet and lying partly in the town of Barrington and partly in the town of Nottingham, hereinafter referred to as the"Mendum Dam". The dams were designed and built very nearly as they are at the present time in or between the years 1839 and 1842.

Type of Dams.

2. In a comprehensive work on "Reservoirs for Irrigation Water Power and Water Supply", published in 1900, Mr. James D. Schuyler, M. Am. Soc. C. E., devotes some seventy-five pages to rock-fill dams. His discussion in part follows:

> "Rock-fill dams may be said to have originated forty or fifty years ago in the mining districts of California.....in difficult and almost inaccessible locations.....and were considered to be of a temporary nature.....They began with timber or log cribs filled with loose stone. Their next stage was an embankment of loose stone, a portion of which was laid up as a dry wall with a facing of two or more thicknesses of plank to secure water tightness. The latter type has proven so serviceable that it is still regardedas one of the most desirable classes of dam that can be built where economy is of prime importance."

Then follows an outline description of six types of rock-fill dams--including these two.

> "2. Rock-fill dams with a central core of steel plates and without hand-laid facing walls."

> "4. Rock-fill dams with facing of masonry built vertically backed with earth and covered on the lower side with blocks of stone laid in mortar."

Now all of these reservoir dams under consideration on the Lamprey water shed are rock-fill dams and not only were they built long before the mining days in California but they

possess permanent features, in the broad puddled clay-and-gravel cores and heavy retaining walls, superior to any of those described by Mr. Schuyler. More information about the design, the designer and the degree of originality in the construction of these dams would be very interesting. It is quite possible that the "type" had its origin in those structures. The dams have caused some anxiety at different dates and changes have been recommended and some have been made at dates that show the existence of faulty work elsewhere rather than in the dams themselves. Soon after the Mill river disaster in Massachusetts, in 1874, and again after the Johnstown flood in 1889, studies were made and the core walls in some places reinforced. In the writer's opinion there has not been a moment since the dams were built that they were unsafe--except from overtopping in some deluge too severe for the spillways to accomodate. It is of eye witness record that the water has been within an estimated "two feet" of the top of the Mendum dam and sand bags have been used on the Pawtuckaway dam No 1 on the water face wall to divert the flood to the spillway. This should not have been necessary.

Pawtuckaway - Dams No. 1, 2 and 3.

3. The dams leak a little. It may be said that all core wall dams do leak. Personal observations for more than two years, and at many different stages of water in the Pawtuckaway reservoir have been recorded, and the leaks in the main Dam (No. 1) measured in a channel constructed for that purpose. The main and waste gates do not close perfectly, but well enough for all reservoir purposes. Some water escapes at the gates--

some through the dam itself--but all that comes through the core wall is always perfectly clear, and a recent measurement,- November 18,- when the surface of the water in the reservoir was two and eight tenths feet below the spillway,gives a good idea of present conditions. The total volume discharged was four and eight tenths second feet, of which it was estimated one half leaked through the gates, or reached the stream in the quarter of a mile between the dam and the measuring channel. The leakage is nearly the same in volume from each half of the dam as may be observed where it flows laterally along the buttressed lower slopes of the dam to the main gateway, the sides of which are walled up vertically from the creek bed. The volume discharged is not large considering the extent of the core wall and the pressure to which it is subjected. A recently examined earth and core wall dam, built over forty years ago in another State, could well be cited here. The dam was more than a fourth of a mile long and about thirty-five feet high. From the first there was leakage. More material was added at the foot of the water slope. Able engineers were called and accurate gaging kept for many years and recorded in annual reports. Following one of these is the comment,-

> "The only variation in the discharge from the weirs appears to be due to changes in the weather."

The same statement would doubtless hold good at the Pawtuckaway and Meridum reservoirs were they accurately gaged. The early water supply for London, England, was from springs that were carefully gaged as the demand increased. Then it was observed that the discharge was greater before than it was after a rain storm.

Their records were virtually barometer readings.)

Gate Repairs.

4. The main gates at the Mendum reservoir set in a wood from had suffered from decay making it difficult to fix upon a satisfactory estimate of leakage. Rocky creek-bed conditions below the dam interposed further difficulties. But nothing serious was observed. The gates and gate frames have just been renewed as you directed, necessary pointing in their vicinity attended to and the reservoir is now filling.

Report by Mr. W. M. Oliver, C. E.

5. In the year 1889 Mr. Oliver made a very comprehensive and valuable report upon all of these dams for the Newmarket Manufacturing Company, and this report with maps, sketches and figures is now in your possession. The maps and cross sections have been checked up carefully and found to be surprisingly accurate. This includes restored base-line measurements and distances to faces of walls. Also deep excavations were made at Mendum's to show that his cross sections were reliable. The more essential sections have been copied freely and are shown in the ink prints attached hereto with well deserved credit to Mr. Oliver in each case.

Recommendations.

6. At Pawtuckaway Dam No. 1 the main gate is at the original level of the stream and is about twenty inches by fifty inches (20" x 50"). It is raised by a wood stem with nut and screw. The stem and timber support within the gate house should be renewed at no distant date. Between this gate and the spillway there are two waste gates each three feet by three feet (3' x 3')

with stems of wood and ratchet connections. These gates are evidently of later construction and are backed up by brick work and two or three braces of wood extending to the solid ledge below the dam where the ends are bolted down. It would be simple and good construction to spring a brick arch between the vertical stone walls to hold the gate frames in place. It is within reason to think that the brick work and braces were placed asthey are so that under certain pressures due to flood conditions, and perhaps with a little help, the whole construction, brick work, gates and timbers would be swept out of the way, much increasing spillway capacity. But whether that inference be correct or not, there can be no apparent harm in leaving the structure in its present condition or in replacing the wood braces when that becomes necessary.

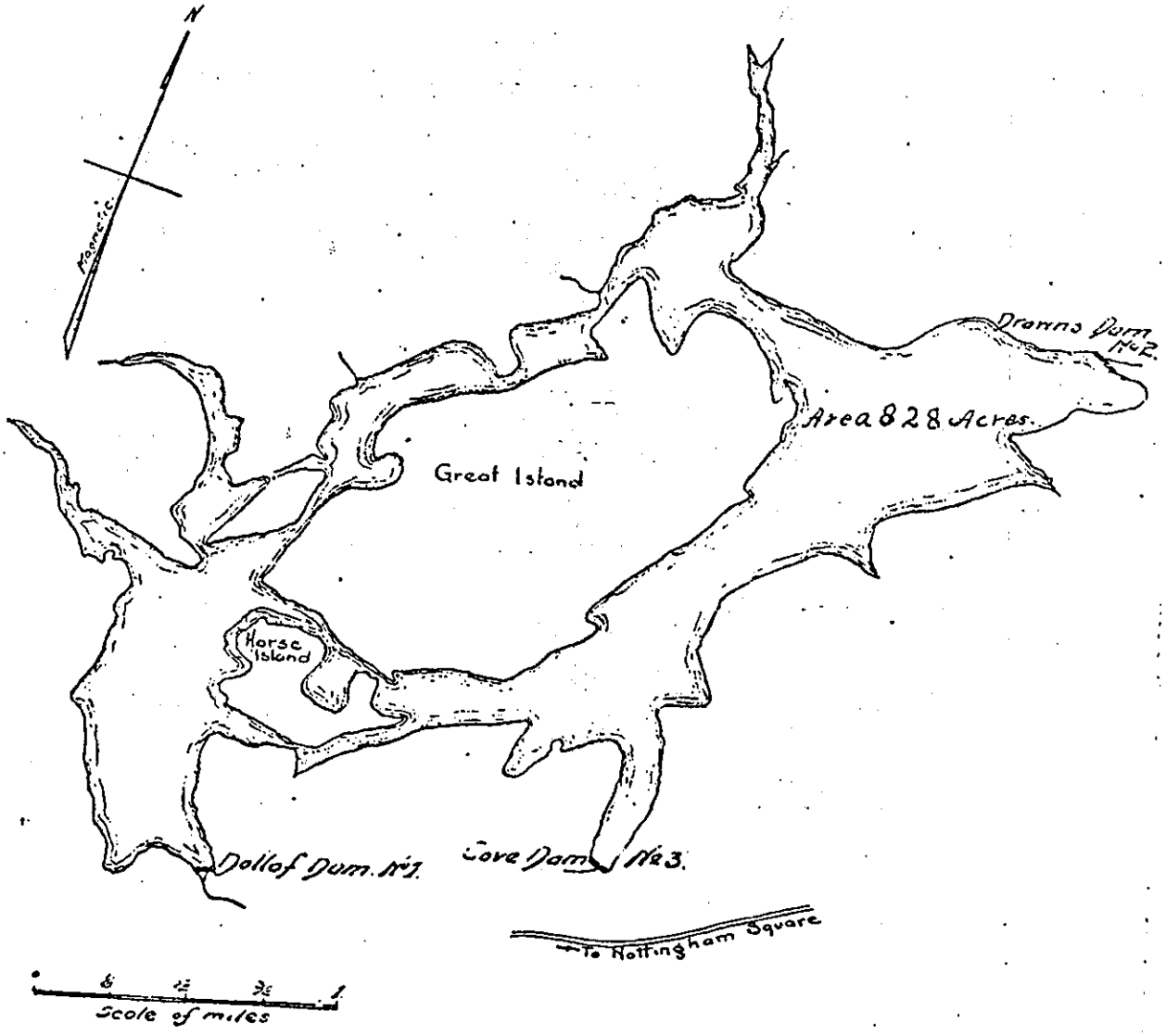
At the Drown Dam (No.2) there are stop planks retained by timber braces more or less decayed. Renewals should be made as time may require. But all of the Pawtuckaway spillways real and imaginery, taken together, are insufficient for a drainage area of twenty (20) square miles. This can be shown conclusively by precipitation records personally witnessed where the annual totals are below those of southern New Hampshire. To provide more ample spillway capacity the Gove Dam (No.3) should be lowered or reduced in elevation about three feet over a length of two hundred and fifty feet in two sections of one hundred and twenty-five feet each as shown in Fig. 1 in the last sheet hereto attached. This will afford in addition to the other spillways a free flow for a great volume of water whenever the necessity arises. That may not be once in a century.

Mendum's.

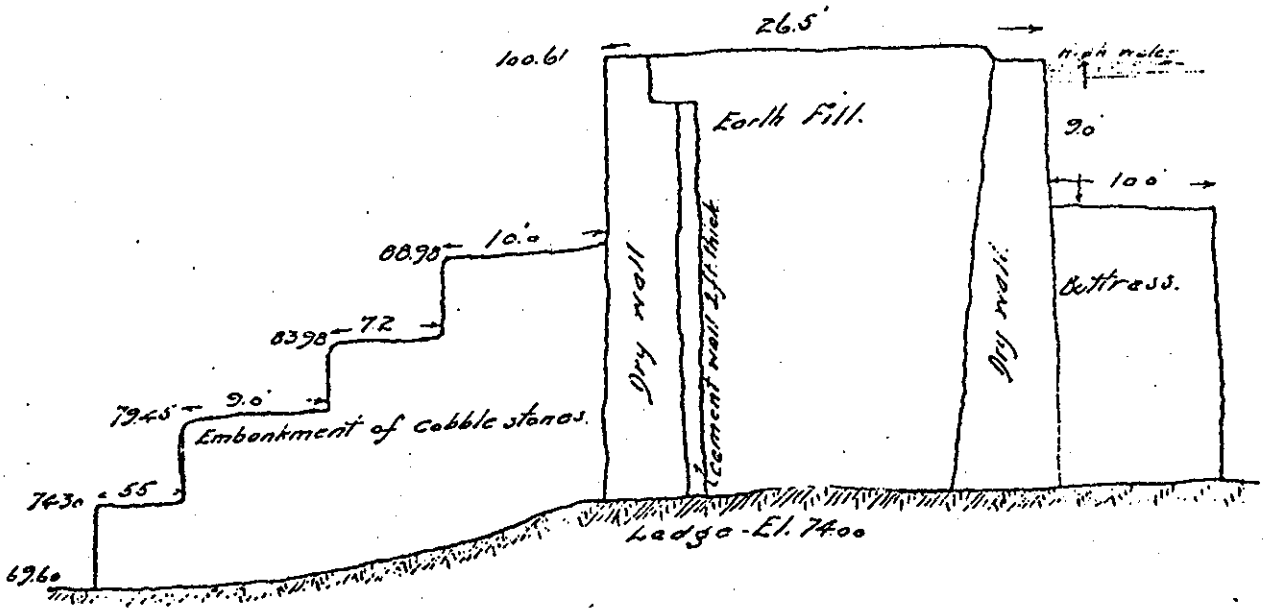
At the Mendum reservoir there is less need to make changes. The bottom of the present spillway should be brought to a uniform level and all growth of small trees and obstacles of all descriptions, driftwood, old stumps, etc. should be removed and the entire space kept clear. One further recommendation needs attention at your convenience. The upstream wall at Mendum's is of very large rough stone, boulders for the most part, and at two or three places these have cracked under the pressure which has been concentrated at various points by the removal, through frost action in nearly a hundred years, of many of the smaller stones used in construction to level up and give added bearing surface. Last month many restorations to early conditions were made by replacement without mortar, but with much work and careful attention to strengthening the wall. There are however three places where steel tie-rods should be introduced at a depth of about eight feet from the surface to check further outward movement at points where the overhang or bulging amount to 12 or 14 inches. The tie-rods should be not less than $2\frac{1}{2}$ inches in diameter with upset ends and provided with washers or crabs 3 or 4 feet in diameter. The location of the rods and a section is shown in Fig. 2 on the last sheet attached to this report. The rods should be free from rust bedded and packed in fine gravel concrete in proportions 1, 2, 3. Very little need be used. The exposed parts should be painted. Then with general supervision and economic control the reservoirs should continue for a long time to give good service without causing you any anxiety or disquiet.

Yours truly,

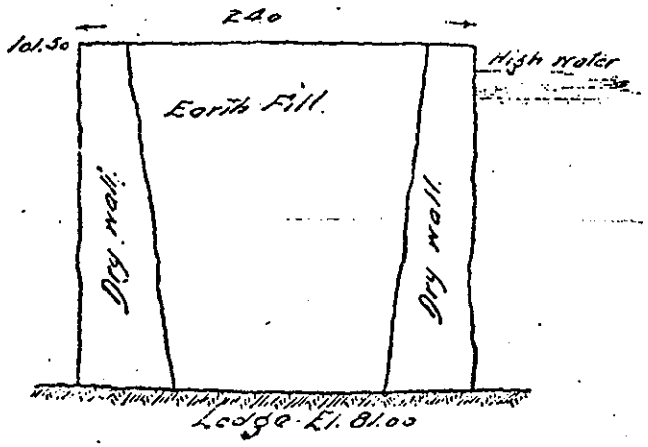
H.F.D./R.



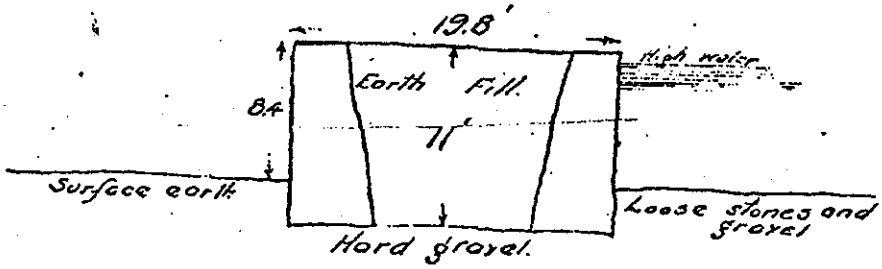
Plan of
PAWTUCKAWAY RESERVOIR
Nottingham NH
Reduced from a plan made by
Wm Walker and dated 1839
Reduced by J.H. Lickfield 1918
Scale 2 mile to the inch.



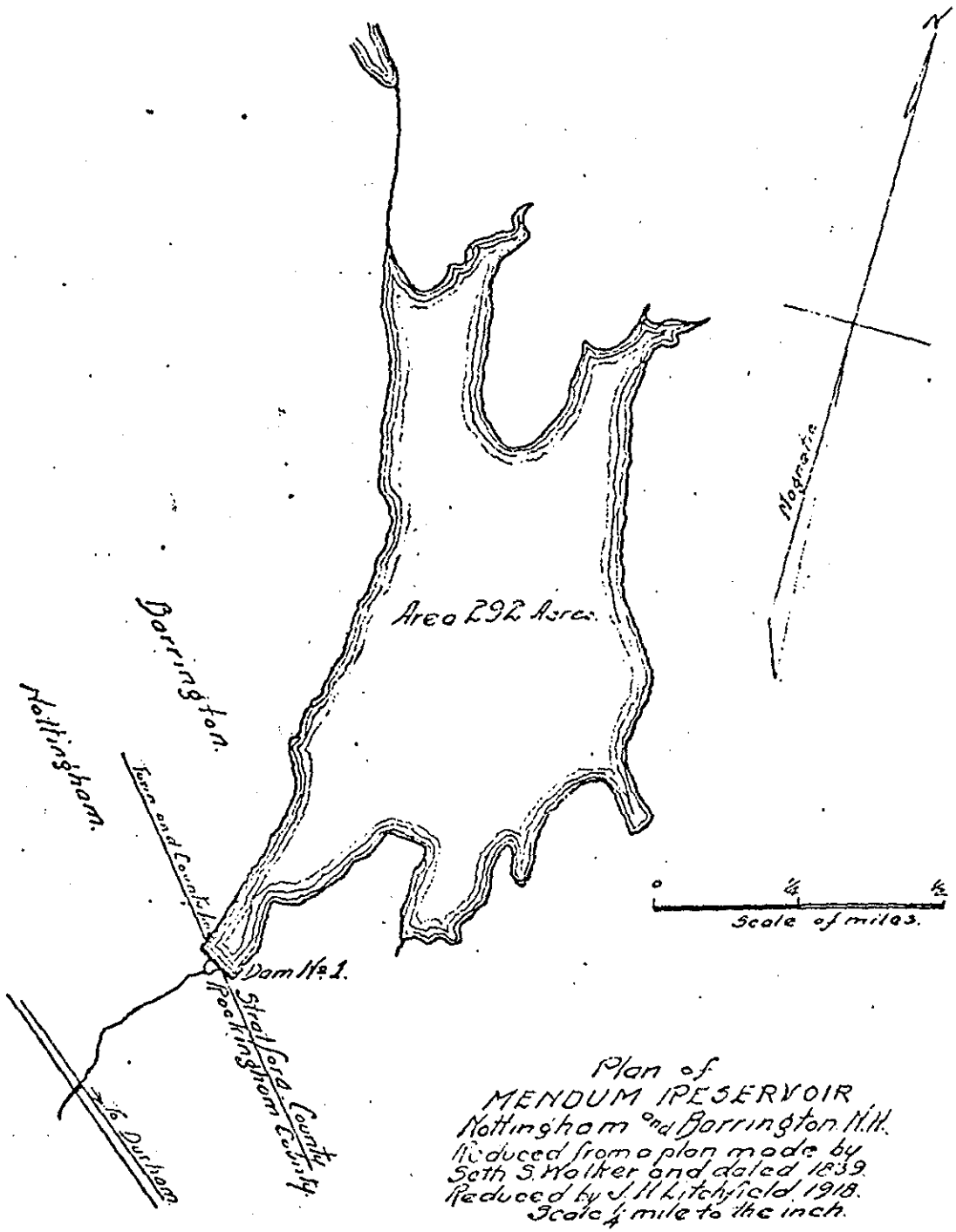
Cross Section
of
DOLLOF DAM. (No 1)
Nottingham N.H.
Scale 10' to the inch.
Copied Nov. 1918. by J.H. Litchfield
from drawings in a report by
H.M. Oliver C.E. to the Nemmorket
Manufacturing Co. dated 1869.



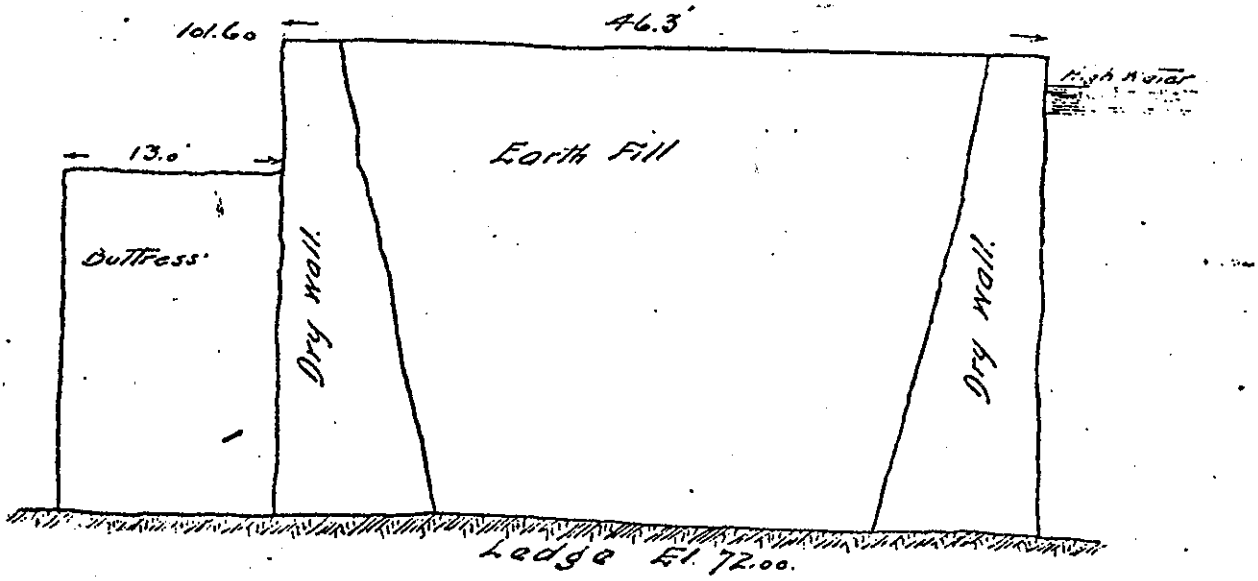
Cross Section
of
DROWN'S DAM (No. 2)
Nottingham NH.
Scale 10' to the inch
Copied Nov. 1918. by J.H. Litchfield.
from drawings in a report by
W.M. Oliver C.E. to the Normarket
Manufacturing Co. dated 1889.



Cross Section
of
GOVE DAM. (No 3)
Nottingham N.H.
Scale 10' to the inch
Copied Nov. 1918. by J.H. Litchfield
from drawings in a report by
H.M. Oliver C.E. to the Newmarket
Manufacturing Co. dated 1889.



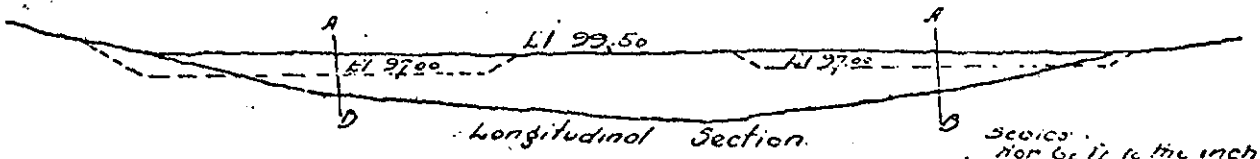
Plan of
MENDUM RESERVOIR
Nottingham and Barrington N.H.
Reduced from a plan made by
Seth S. Walker and dated 1839.
Reduced by J. H. Litchfield 1918.
Scale ¼ mile to the inch.



Cross Section
of
MENDUM DAM
Nottingham & Barrington N.H.
Scale 10' to the inch
Copied Nov. 1918 by J.H. Litchfield
from drawings in a report by
W.M. Oliver C.E. to the Newmarket
Manufacturing Co. dated 1889.

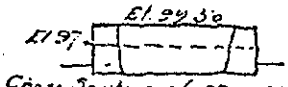
Changes to be made at Gore Dam (No 3)

Fig. 1.



Longitudinal Section.

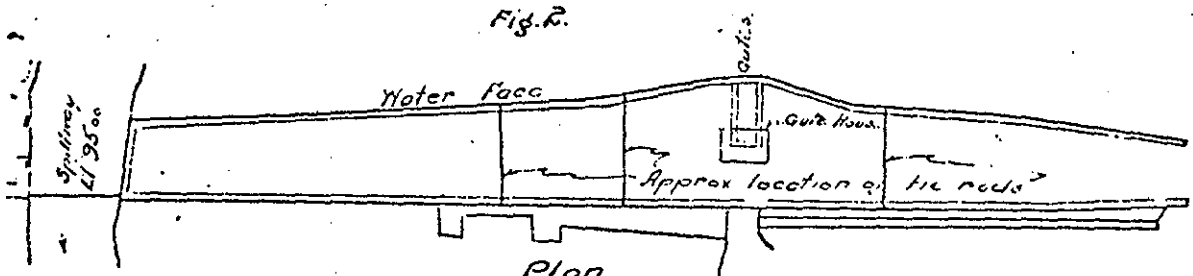
Scales:
Hor 66 ft to the inch
Vert 20 ft to the inch



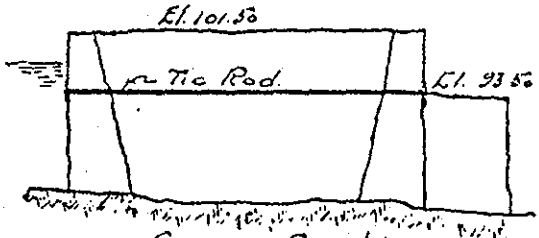
Cross Section of proposed spillway at N.B.
Scale: 20 ft to the inch.

Changes to be made at Mendum Dam.

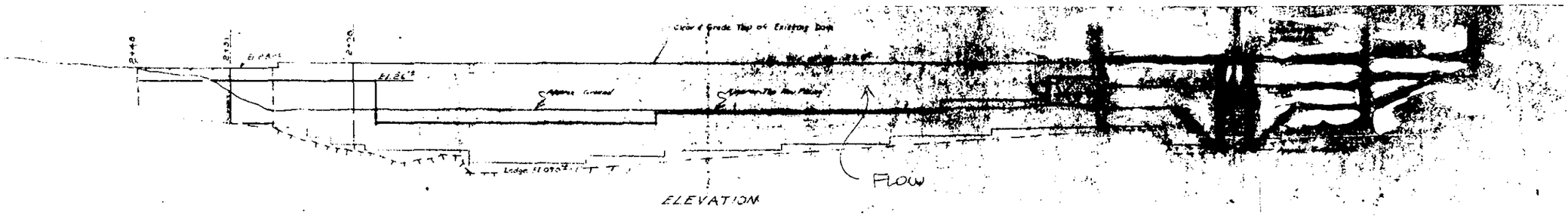
Fig. 2.



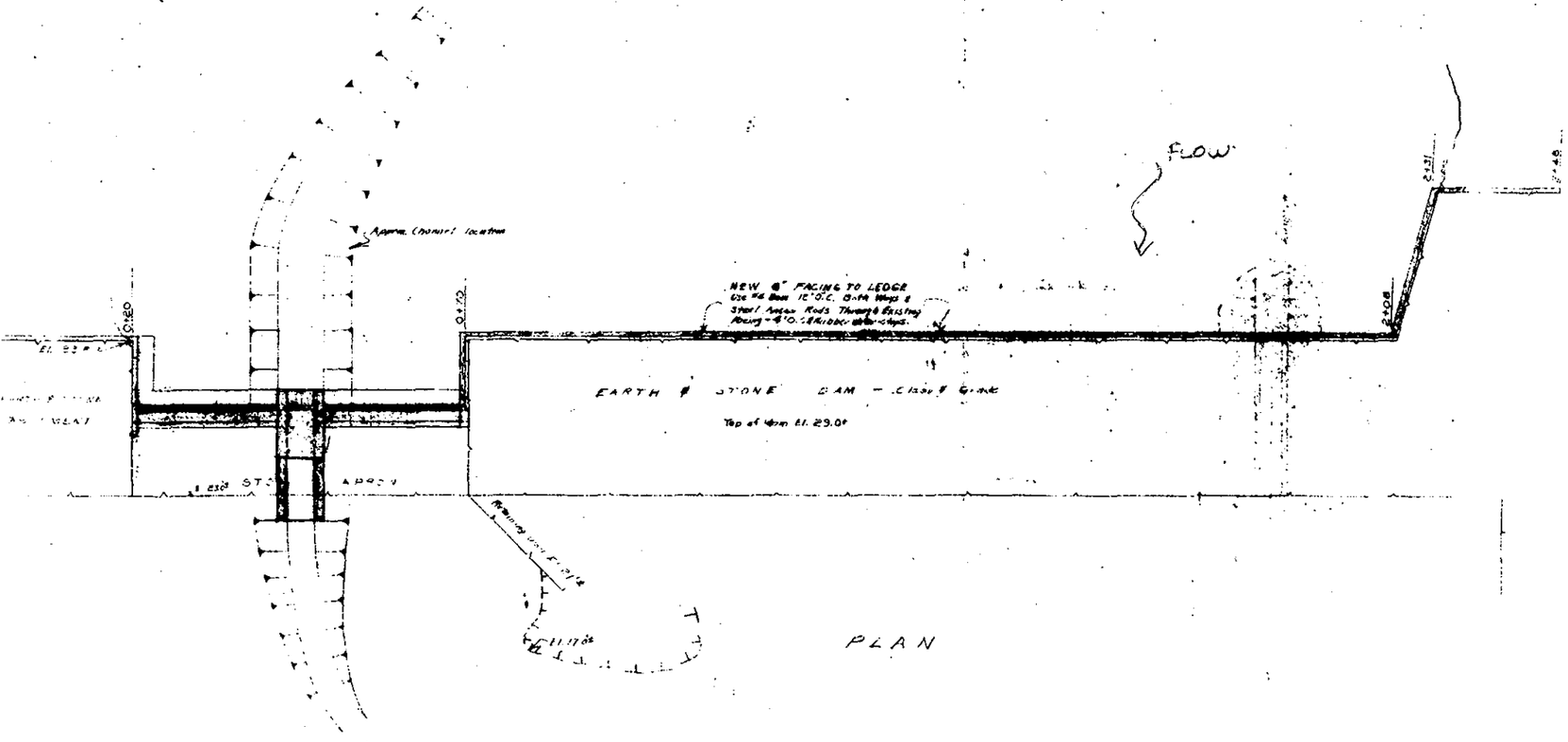
Plan. Scale:- 60 ft to the inch.



Cross Section.
Scale:- 20 ft. to the inch.



ELEVATION



PLAN

NOTES

DROWNS DAM RECONSTRUCTION

PLAN & ELEVATION

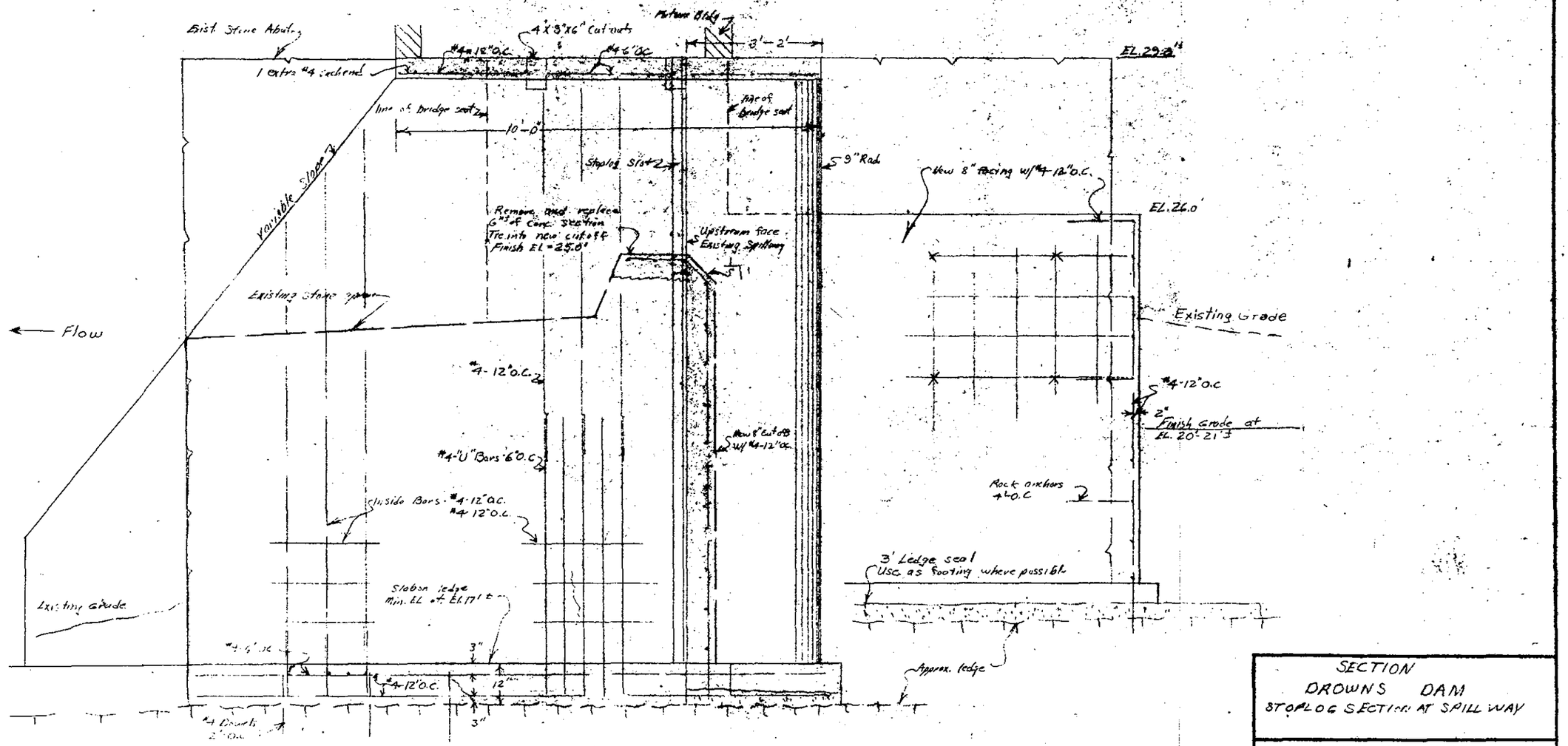
NOTTINGHAM, N.H. 8/1804

NEW HAMPSHIRE WATER RESOURCES BOARD
- CONCORD, N. H. -

SCALE

SHEET 1 OF 4 SHEETS

DATE



SECTION
DROWNS DAM
STOPLOG SECTION AT SPILL WAY

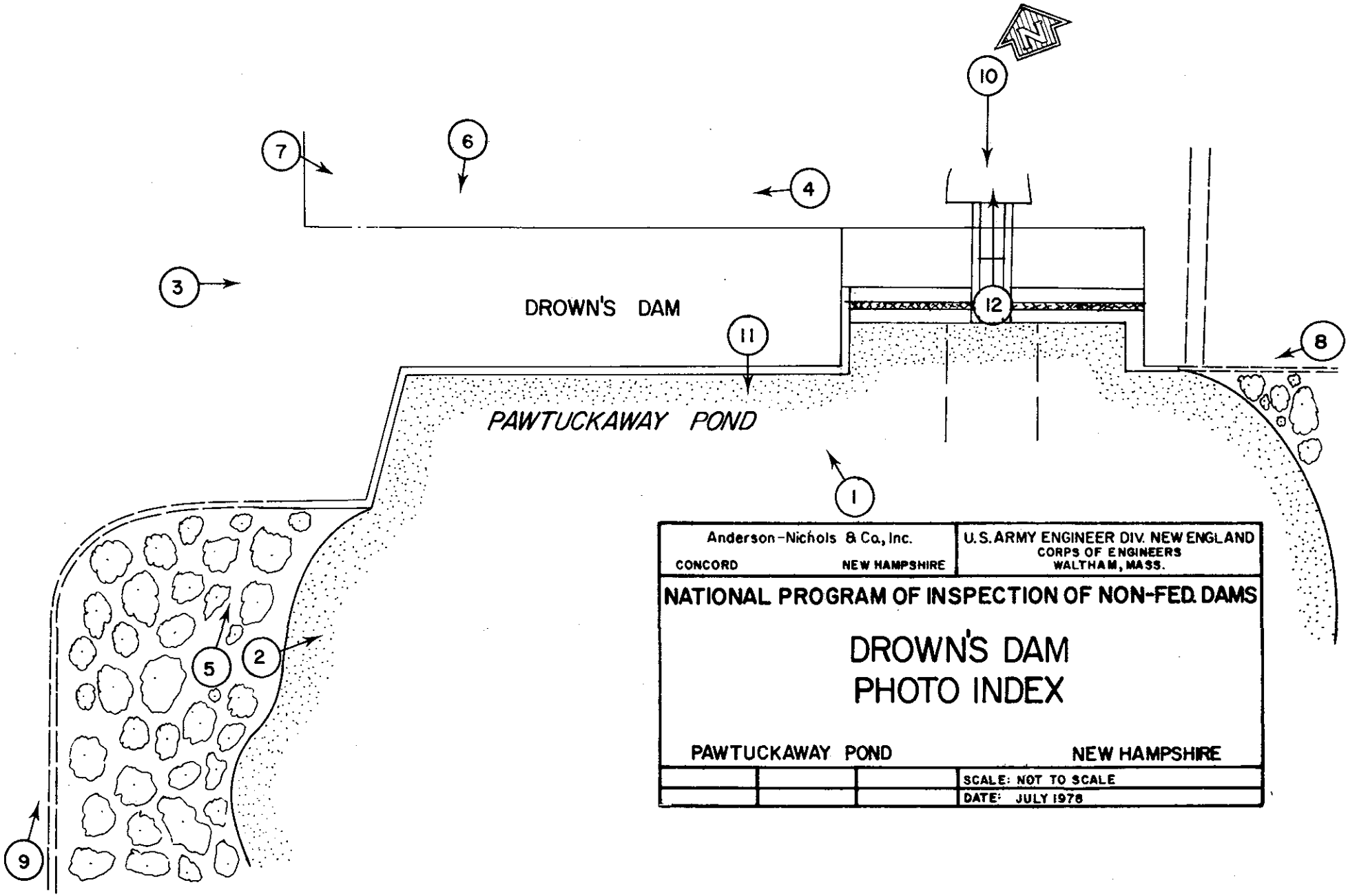
NEW HAMPSHIRE
WATER RESOURCES BOARD
CONCORD, N. H.

Scale	Sheet	Date
1"=2'	Sheet 3 of 3 Sheets	Jan 9 1964

N BY
KED BY

APPENDIX C

PHOTOGRAPHS



Anderson-Nichols & Co., Inc. CONCORD NEW HAMPSHIRE	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

DROWN'S DAM
PHOTO INDEX

PAWTUCKAWAY POND NEW HAMPSHIRE

SCALE: NOT TO SCALE

DATE: JULY 1978

Figure 2 - View of the upstream face of Drown's Dam taken from the west bank.

Figure 3 - Looking southeast along the center of the dam from the northwest abutment.

Figure 4 - Looking northwest at the downstream face of the dam.

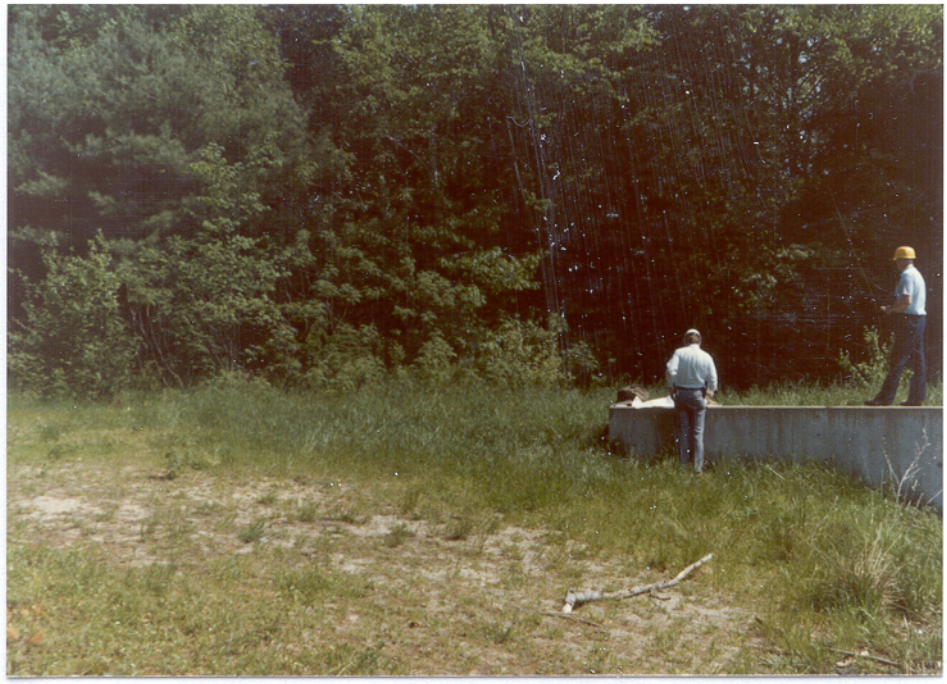


Figure 5 - Looking northeast at the emergency spillway located at the northwest end of the dam.

Figure 6 - Looking at the downstream face of the dam. Note the 48 inch penstock, partially filled with rubble and concrete, and the seepage coming from this area.

Figure 7 - Seepage at the downstream toe of the dam about 80 feet from the northwest abutment. Note the tree stump near the top of the dam at the right edge of the photo.

Figure 8 - Looking west at the upstream face of the east dike.

Figure 9 - View looking north along the downstream face of the west dike.

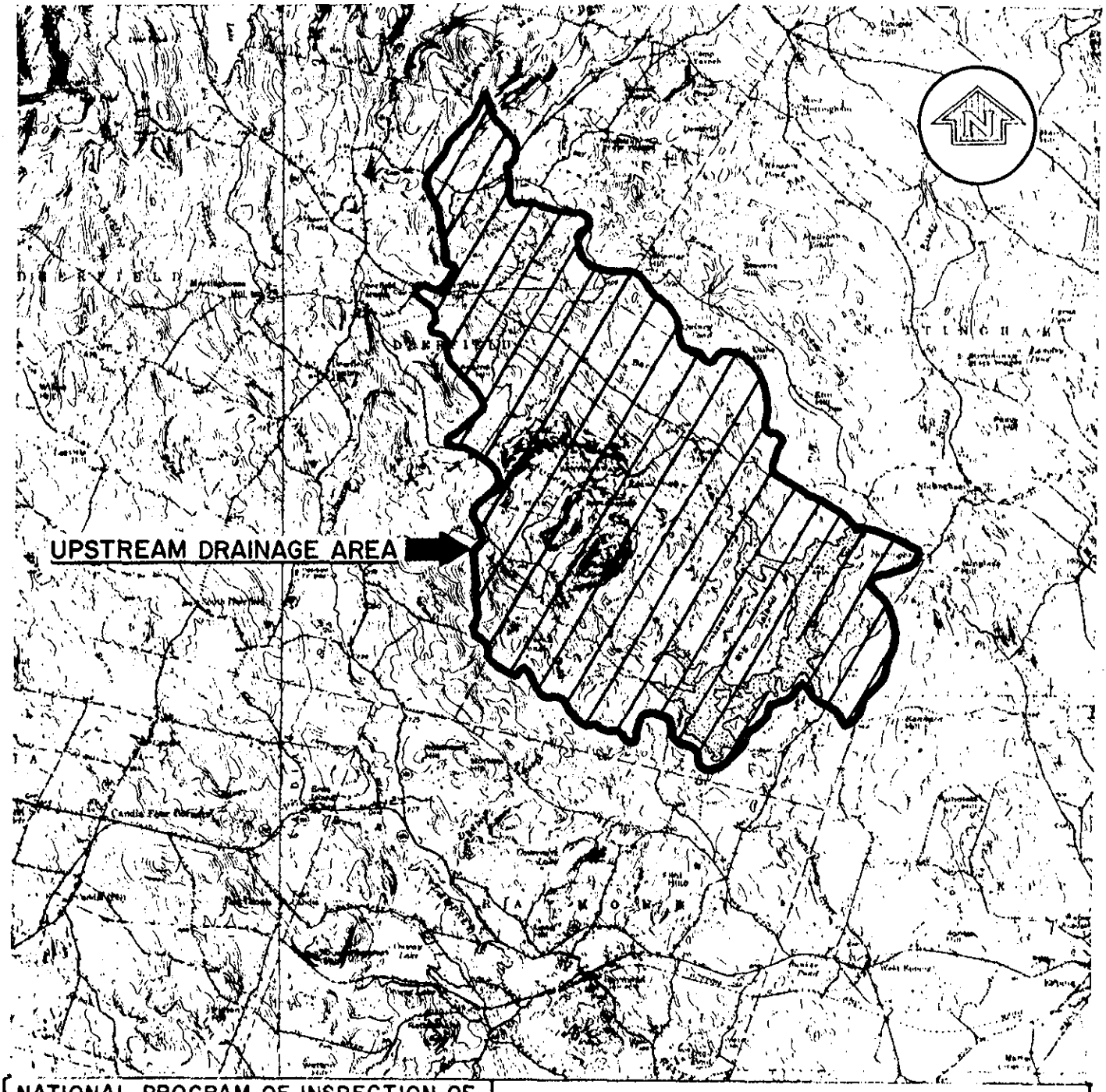
Figure 10 - Looking upsteam at the overflow spillways and the narrow stoplog spillway.

Figure 11 - Looking upstream at Pawtuckaway Pond from the center of Drown's Dam.

Figure 12 - Looking at the channel downstream of the spillways from the service bridge.

APPENDIX D

HYDROLOGY/HYDRAULICS



NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS
PAWTUCKAWAY POND
DROWN'S DAM
NOTTINGHAM, NEW HAMPSHIRE

REGIONAL VICINITY MAP

JULY 1978

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS

ANDERSON NICHOLS & CO., INC CONCORD, NH

SCALE IN MILES

1 ½ 0 1 2 3

MAP BASED ON U.S.G.S. 15 MINUTE QUADRANGLE
SHEET SUNCOOK, N.H. 1957 and
Mt. PAWTUCKAWAY, N.H. 1957

H/H
DROWN'S DAM

1 of 8

HYDROLOGY

6/29/78
P.O

PAWTUCKAWAY LAKE

STEP 1: PROBABLE MAXIMUM FLOOD DETERMINATION (PMF)

RE: PRELIMINARY GUIDANCE FOR ESTIMATING MAXIMUM PROBABLE DISCHARGES IN PHASE I DAM SAFETY INVESTIGATIONS, NED - COE, MARCH 1978

USING FLAT & COASTAL CURVE TO DETERMINE PMF PEAK INFLOW

DA = 19.9 square miles (ANG)
DA = 20.66 " " (WRB)
DA = 18.0± " " (Public Service Commission)
DA = 21 " " (COE 74)
@ DA = 20.66 square miles

PMF = 590 cfs / sq mile

$$PMF = \frac{590 \text{ cfs}}{\text{sq mile}} \times 20.66 \text{ sq miles}$$

PMF = 12,200 cfs (Q_{PI})

HYDROLOGY

7/7/78
BO

FRANCKAWNY LAKE

STEP 2: a Q_{P_1} = PMF = 12,200 cfs

SURCHARGE HEIGHT TO PASS Q_{P_1}

RE: HYDRAULIC BACKUP FOR EACH INDIVIDUAL STRUCTURE; IE: RATING CURVES

TRIAL 1 — elev = 28.6

GOVE DIKE	=	0
DROWN'S DAM	=	823 cfs
DOLLOFF DAM	=	1096 cfs
		1919 cfs

TRIAL 2 — elev = 30.0

GOVE DIKE	=	617 cfs
DROWN'S DAM	=	1636
DOLLOFF DAM	=	2243
		4496 cfs

TRIAL 3 — elev = 31.0

GOVE DIKE	=	1455
DROWN'S DAM	=	2787
DOLLOFF DAM	=	3842
		8084 cfs

TRIAL 4 — elev @ 32.0

GOVE DIKE	=	3382
DROWN'S DAM	=	5062
DOLLOFF DAM	=	6427
		14,871 cfs

HYDROLOGY
DAWNTUCKAWAY LAKE

7/7/78
BO

FROM THE ABOVE TRIALS A RATING CURVE FOR THE LAKE CAN BE DRAWN. READING THE ELEVATION AT THE PMF

@ PMF = 12,200 cfs
elev = 31.65

GOVE DIKE = 2596 cfs
DOLLOFF DAM = 5430
DROWN'S DAM = 4127
12153 cfs

SINCE THIS IS LESS THAN PMF ROUND ELEVATION UP TO 31.7

∴ SURCHARGE HEIGHT = 31.7 - 25.0 = 6.7'
(ABOVE SPILLWAY)

VOLUME OF SURCHARGE HEIGHT

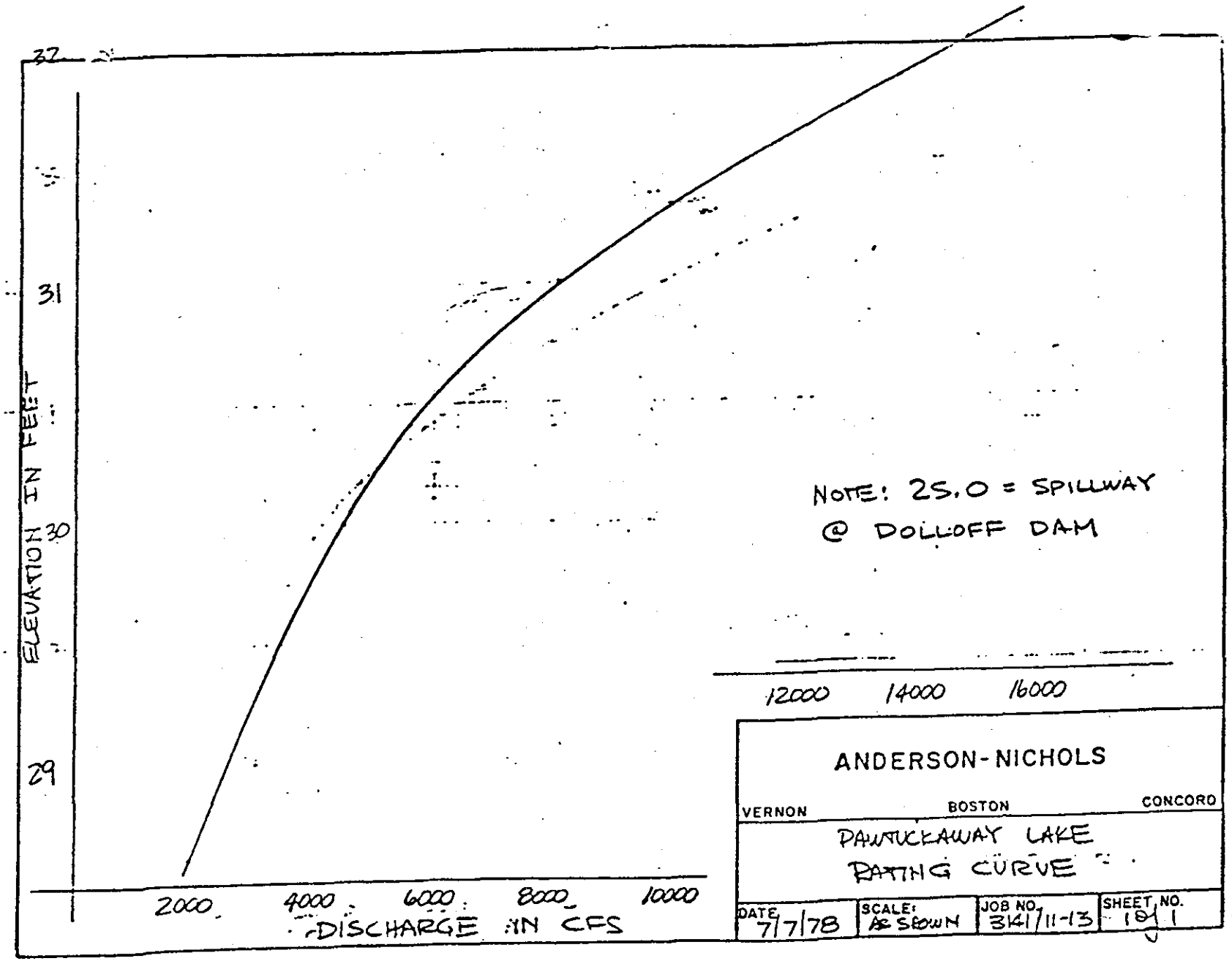
INVENTORY –

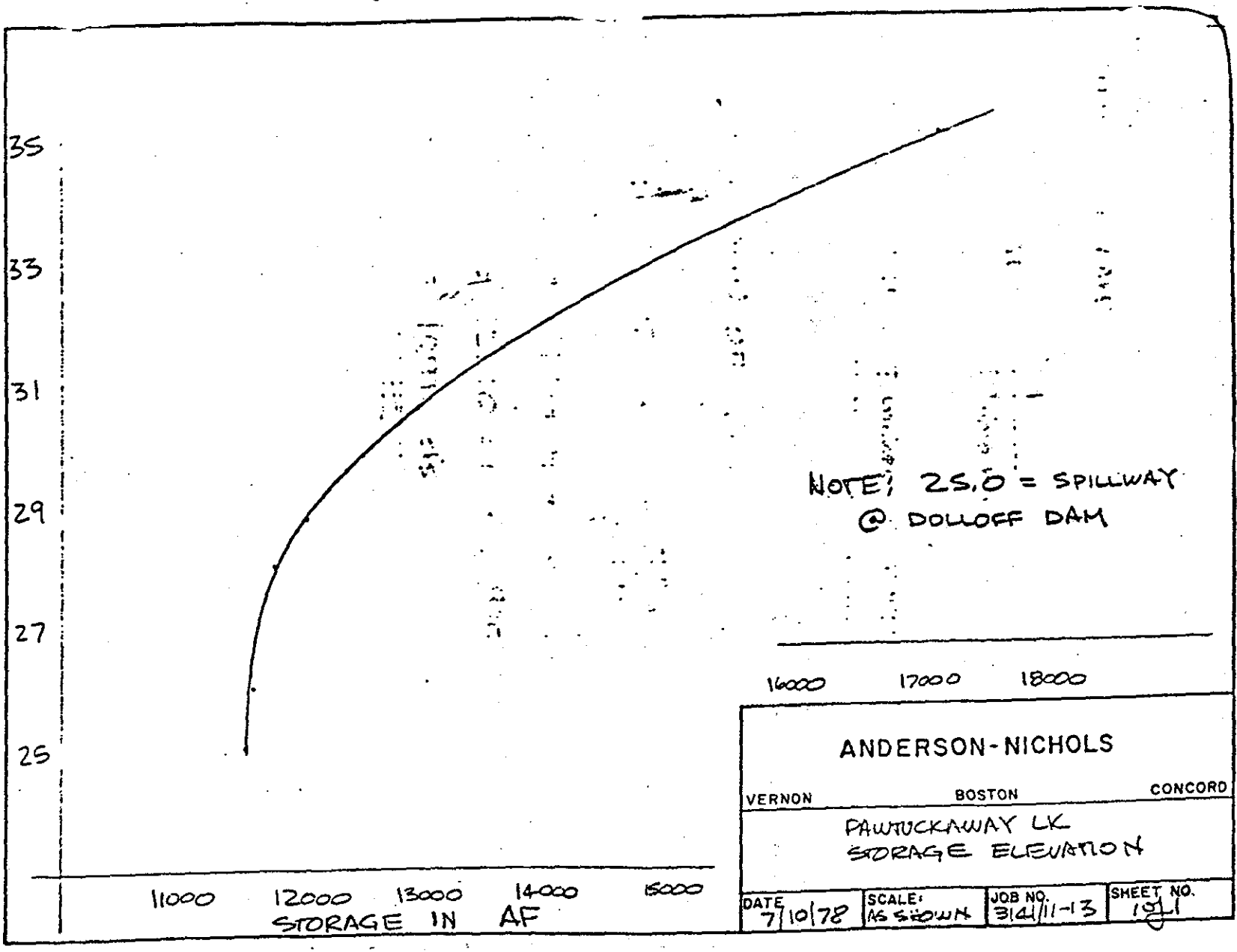
DAM	MAX	NORMAL
Dolloff Dam	14700	11500
Gove Dike	14700	11500
Drown's Dam	14700	11500

normal lake level = 903 A @ elev 25.0 (SPILLWAY)
elevation 260 (QUAD) = 1482 A @ elev 25+10 = 35.0

STOR @ 31.7 = 13700 AF
@ 25.0 = 11500 AF
} see STOR-ELEV

∴ STOR$_1$ (SURCHARGE) = 2200 AF


32
31
30
29
ELEVATION IN FEET
2000
4000
6000
8000
10000
12000
14000
16000
DISCHARGE IN CFS
NOTE: 25.0 = SPILLWAY
@ DOLLOFF DAM
ANDERSON-NICHOLS
VERNON
BOSTON
CONCORD
PAWTUCKAWAY LAKE
RATING CURVE
DATE 7/7/78
SCALE: AS SHOWN
JOB NO. 3141/11-13
SHEET NO. 1 of 1


35
33
31
29
27
25
11000
12000
13000
14000
15000
STORAGE IN AF
16000
17000
18000
NOTE; 25.0 = SPILLWAY
@ DOLLOFF DAM
ANDERSON-NICHOLS
VERNON
BOSTON
CONCORD
PAWTUCKAWAY LK
STORAGE ELEVATION
DATE 7/10/78
SCALE: AS SHOWN
JOB NO. 3141/11-13
SHEET NO. 10.1

HYDROLOGY
FAIRFIELD-PLEASANT VALLEY LAKE

7/10/78
CB

$$2200\ AF \times \frac{1}{20.66\ mi^2} \times \frac{mi^2}{640\ A} = 0.17\ ft$$

0.17 ft = 2 inches of RUNOFF OVER BASIN

C. DETERMINATION OF Q_{P2}

$$Q_{P_2} = Q_{P_1} \times \left(1 - \frac{STOR_1}{19}\right)$$

$$= 12200\ cfs \times (1 - 2/19)$$

$$= 12200\ cfs \times 0.895$$

$$= 10916\ cfs$$

YDROLOGY
PAWTUCKAWAY LAKE

7/10/78
BO

STEP 3 a) SURCHARGE HEIGHT TO PASS Q_{P2}

Q_{P2} = 10916 cfs

FROM RATING CURVE : elev = 31.46

SURCHARGE HEIGHT = 31.46 - 25.0 = 6.46'

FROM STORAGE - ELEVATION CURVE

STOR @ 31.46 = 13500 AF
STOR @ 25.0 = 11500 AF

∴ VOL. OF SURCHARGE = 2000 AF

$$2000\,AF \times \frac{1}{20.66\,mi^2} \times \frac{mi^2}{640\,A} = 0.151\,ft$$

0.151 ft = 1.82 inches over BASIN

b. AVERAGE SURCHARGE & PEAK OUTFLOW (Q_{P3})

$STOR_1$ = 2.0" } AVE = 1.9"
$STOR_2$ = 1.8" }

$$1.9'' \times 20.66\,mi^2 \times \frac{1\,ft}{12''} \times \frac{640\,A}{1\,mi^2} = 2094\,AF$$

2094 AF + 11500 AF = 13594 AF

HYDROLOGY
PAWTUCKAWAY LAKE

7/10/78
BO

FROM STOR-ELEV CURVE:

@ 13594 AF → elev = 31.5

FROM RATING CURVE:

31.5 = 11200 cfs = Q_{P3}

CHECK of ½ PEAK OUTFLOW

½ PEAK OUTFLOW = 5600 cfs

FROM RATING CURVE

5600 cfs → 30.41 ft

BO
7/6/78
3141-13

DROWN'S DAM
RATING CURVE COMPS

$Q = CLH^{3/2}$ ASSUME STOPLOGS IN !!
(25.0 = SPILLWAY)

SPILLWAY FLOW NOT INCLUDING STOPLOG CAPACITY

C = 2.8 FOR SPILLWAY SECTION

@ elev = 25.0 $Q = 0$

@ elev = 25.5

$C = 2.8$
$L = 21' \times 2$
$H = 0.5'$
$Q = CLH^{3/2}$
$= (2.8)(42)(0.5)^{3/2} = 41.6$ cfs

@ elev = 26.0

$H = 1.0'$
$Q = CLH^{3/2}$
$= (2.8)(42)(1)^{3/2} = 117.6$ cfs

@ elev = 26.5

$H = 1.5$
$Q = CLH^{3/2}$
$= (2.8)(42)(1.5)^{3/2} = 216.0$ cfs

elev = 27.0

$H = 2.0$
$Q = CLH^{3/2} = (2.8)(42)(2)^{3/2} = 332.6$ cfs

6. @ elev = 27.5

$H = 2.5$
$Q = CLH^{3/2}$
$= (2.8)(42)(2.5)^{3/2} = 464.9$ cfs

7. @ elev = 28.0

$H = 3.0$
$Q = CLH^{3/2}$
$= (2.8)(42)(3)^{3/2} = 611.1$ cfs

3. @ ELEVATION 28.0+ THE AREA LEFT OF THE STRUCTURE NOW HANDLES A PORTION OF THE FLOW:

@ elev = 28.3

SPILLWAY
$H = 3.3$
$Q = CLH^{3/2}$
$= (2.8)(42)(3.3)^{3/2} = 705.0$ cfs

low pt
$H = 0.3$
$Q = CLH^{3/2}$
$= (2.7)(13')(0.3)^{3/2}$
$= 5.8$ cfs.

NOTE: use C = 2.7 FOR OVERLAND PORTION

$705.0 + 5.8 = 710.8$ cfs

1. @ elev = 28.6

SPILLWAY
$H = 3.6$
$Q = CLH^{3/2}$
$= (2.8)(42)(3.6)^{3/2} = 803.3$ cfs

LOW POINT
$H = 0.3$
$Q = (2.7)(31)(0.3)^{3/2} + 5.8 = 19.6$ cfs

$803.3 + 19.6 = 822.9$ cfs

0. @ elev 28.6 + the area right of the structure now handles a portion of the flow

@ elev 29.0

spillway → $Q = (2.8)(42)(4.0)^{3/2}$ = 940.8 cfs
L OVER → $Q = (2.7)(37)(0.7)^{3/2} + 58$ = 64.3
R OVER → $Q = (2.7)(5.5)(0.4)^{3/2}$ = 3.8
1008.9 cfs

. @ elev 29.5

SPILLWAY → $Q = (2.8)(42)(4.5)^{3/2}$ = 1122.6
L OVER → $Q_1 = (2.7)(59)(0.2)^{3/2}$ = 14.2
$Q_2 = (2.7)(42)(1.0)^{3/2} + 5.8$ = 119.2
R OVER → $Q = (2.7)(57)(0.5)^{3/2} + 38$ = 58.2
1314.2 cfs

2. @ elev 29.8 → TOP OF DAM

SPILLWAY → $Q = (2.8)(42)(4.8)^{3/2}$ = 1236.7
L OVER → $Q = (2.7)(59.5)(0.5)^{3/2} + 119.2$ = 176.0
R OVER → $Q = (2.7)(122)(0.3)^{3/2} + 58.2$ = 112.3
1525.0 cfs

3. @ elev 30.0

SPILLWAY + LOVER + ROVER ⇒ Q = 1525.0
OVER TOP → $Q = (2.7)(460)(0.2)^{3/2}$ = 111.1
1636.1 cfs

14. @ elev 30.4

SPILLWAY + L.O. + R.O. Q = 1525.0
OVER TOP → $Q = (2.7)(489)(0.6)^{3/2}$ = 613.6
2138.6 cfs

15. @ elev 31.0

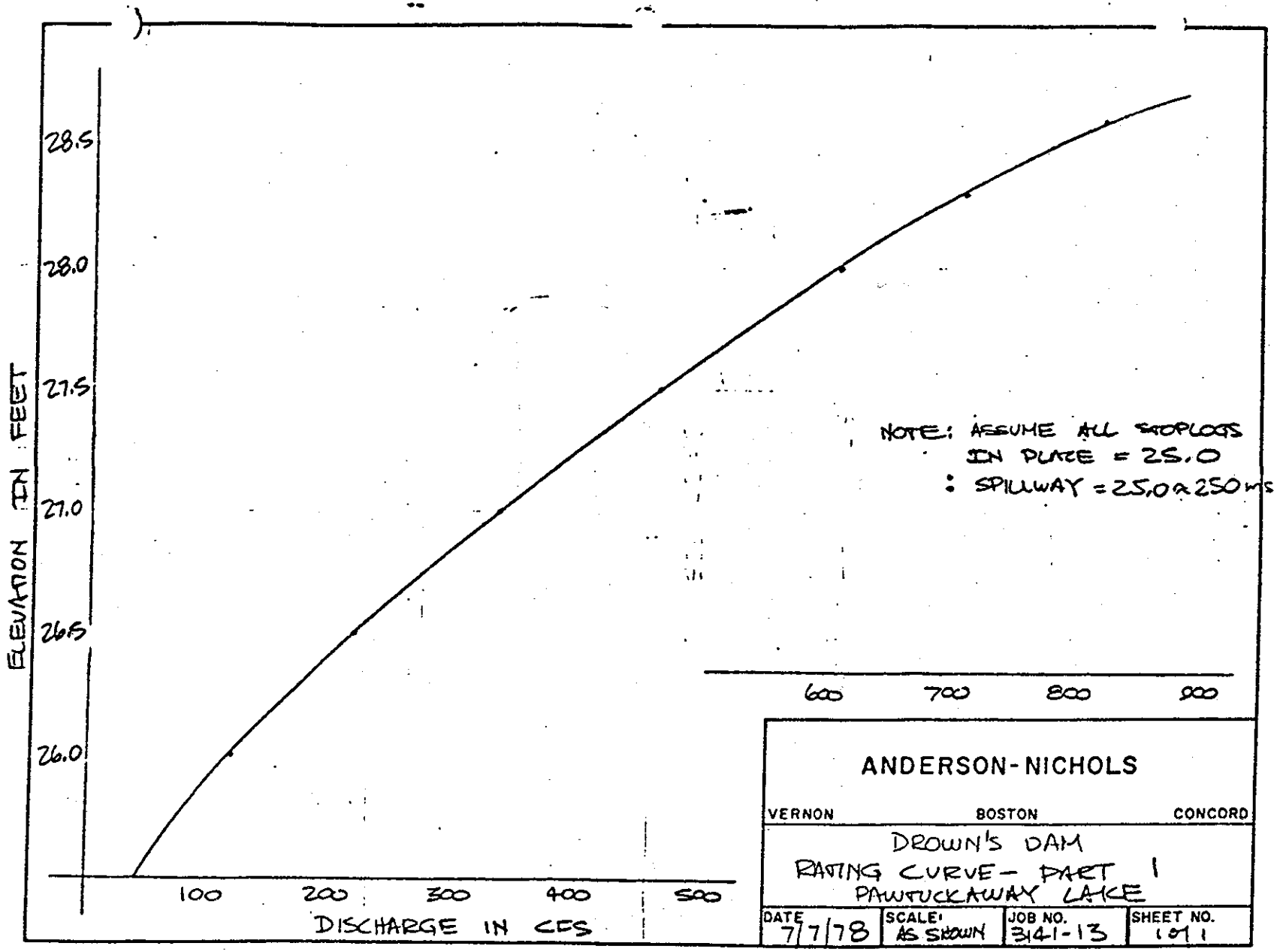
SPILLWAY + L.O. + R.O. Q = 1525.0
OVERTOP → $Q = (2.7)(517)(0.6)^{3/2} + 613.6$ = 1262.4
2787.4

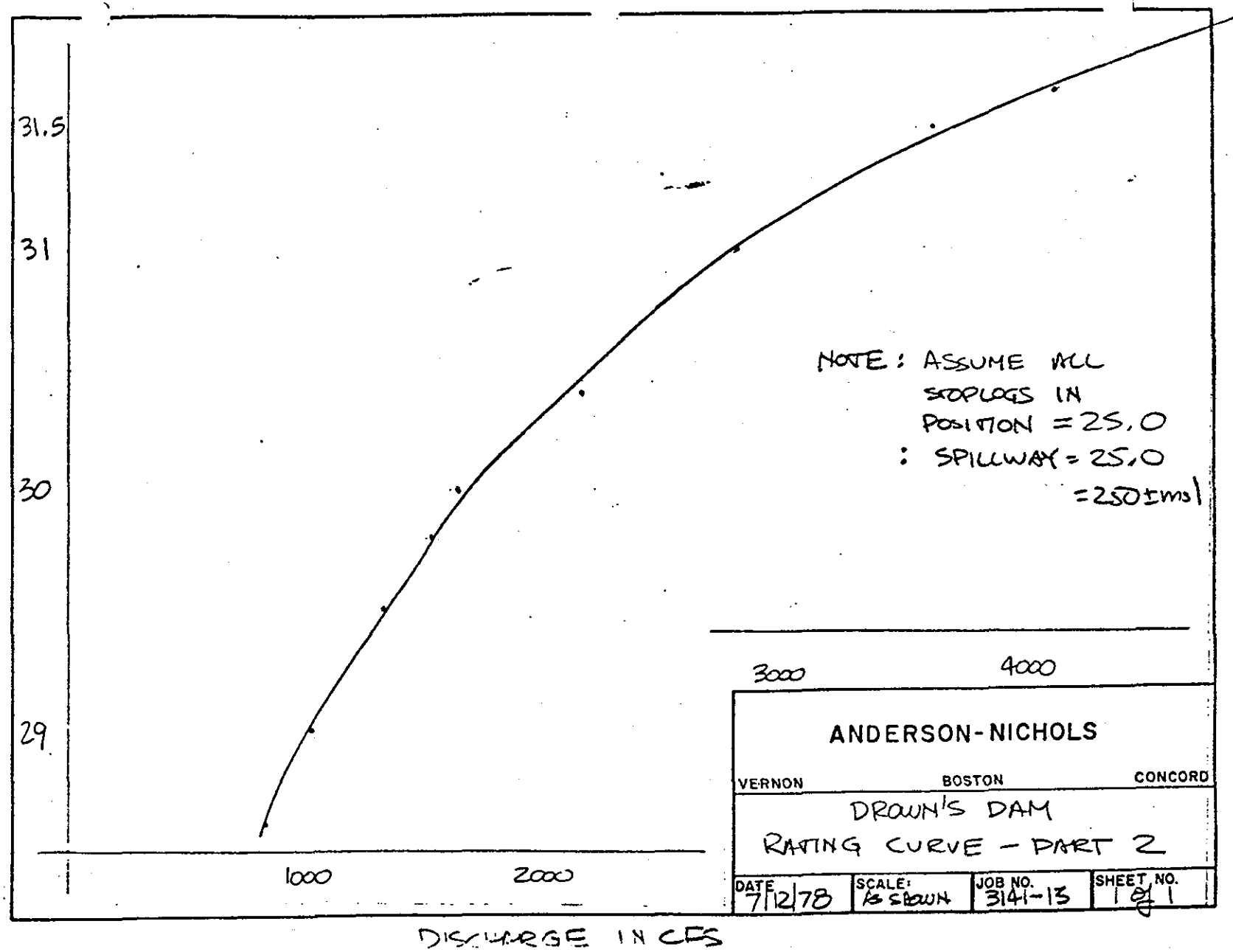
6. @ elev 32.0

BELOW TOP OF DAM Q = 1525.0
OVERTOP OF DAM $Q = (2.7)(535)(1.6)^{3/2}$ = 2923.5
613.6
5062.1

17. @ elev 31.65

BELOW TOP OF DAM Q = 1525.0
OVERTOP OF DAM $Q = (2.7)(527)(1.25)^{3/2}$ = 1988.6
613.6
4127.2


28.5
28.0
27.5
27.0
26.5
26.0
ELEVATION IN FEET
100
200
300
400
500
600
700
800
900
DISCHARGE IN CFS
NOTE: ASSUME ALL STOPLOGS IN PLACE = 25.0
: SPILLWAY = 25.0 @ 250 cfs
ANDERSON-NICHOLS
VERNON BOSTON CONCORD
DROWN'S DAM
RATING CURVE - PART 1
PAWTUCKAWAY LAKE
DATE 7/7/78
SCALE: AS SHOWN
JOB NO. 341-13
SHEET NO. 1 of 1


31.5
31
30
29
ELEVATION IN FEET
1000
2000
3000
4000
DISCHARGE IN CFS
NOTE: ASSUME ALL STOPLOGS IN POSITION = 25.0
: SPILLWAY = 25.0
=250±ms|
ANDERSON-NICHOLS
VERNON BOSTON CONCORD
DROWN'S DAM
RATING CURVE - PART 2
DATE 7/12/78
SCALE: AS SHOWN
JOB NO. 3141-13
SHEET NO. 1 of 1

PAWTUCKAWAY LAKE
DROWN'S DAM
(30 8/16/78
DOWNSTREAM HAZARD

ASSUME FAILURE AT FULL POOL CONDITIONS.
FULL POOL IS DEFINED AS MAXIMUM POOL

DROWN'S DAM
MAX POOL = 252.7 MSL

PEAK FAILURE OUTFLOW FROM BREACH:

$$Q_B = \left(\frac{8}{27}\right)(W_b)\sqrt{g}\, y^{3/2}$$

W_b = BREACH WIDTH
g = 32.2 ft/sec²
y = POOL LEVEL → RIVER BED

ASSUMING OTHER STRUCTURES HOLD ; BREACH WIDTH = 60 FEET

REACH 1 DAM TO TOWN ROAD

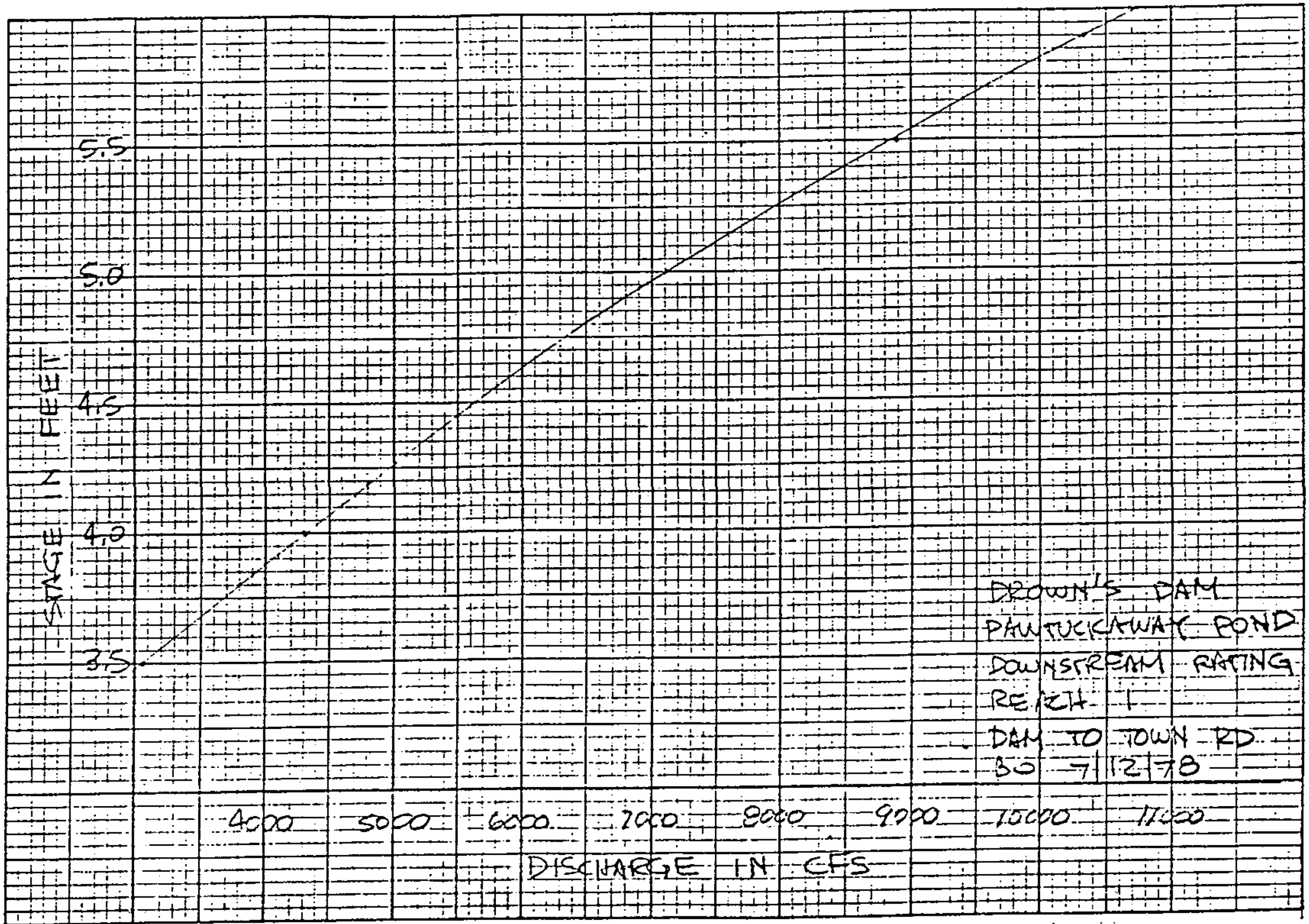
$$Q_B = \left(\frac{8}{27}\right)(60)\left(\sqrt{32.2}\right)(252.7 - 239.0)^{3/2}$$
$$= 5115 \text{ cfs}$$

OTHER DISCHARGE IN REACH FROM DAM = 520 cfs

TOTAL Q in REACH = 5115 + 520 = 5635 cfs

FROM D/S HAZARD REACH 1 RATING CURVE:

STAGE @ 5635 cfs = 4.5 FEET


STAGE IN FEET
3.5
4.0
4.5
5.0
5.5
4000
5000
6000
7000
8000
9000
10000
11000
DISCHARGE IN CFS
DROWN'S DAM
PAWTUCKAWAY POND
DOWNSTREAM RATING
REACH 1
DAM TO TOWN RD
BO 7/12/78

REACH 1's LENGTH = 2000' ±

VOLUME WITHIN REACH = V_1

$V_1 = 2000 \times 2000 = 92$ AF

STORAGE @ MAX POOL = 11700 AF = S

since $V_1 < \frac{1}{2} S$ ∴ REACH ok

$Q_2 = Q_1 (1 - V_1/S)$

$= 5635 (1 - 92/11700) = 5590$ cfs

STAGE @ 5590 cfs = 4.5 FEET

SINCE THIS WOULD RESULT IN SAME VOLUME WITHIN THE REACH

$Q_{Reach\ 1} = (5590 + 5635)/2 = 5600$ cfs

@ Q = 5600 cfs
STAGE FOR REACH 1 = 4.5 FEET
STORAGE WITHIN REACH = 92 AF

REACH 2 ROAD → TOWN

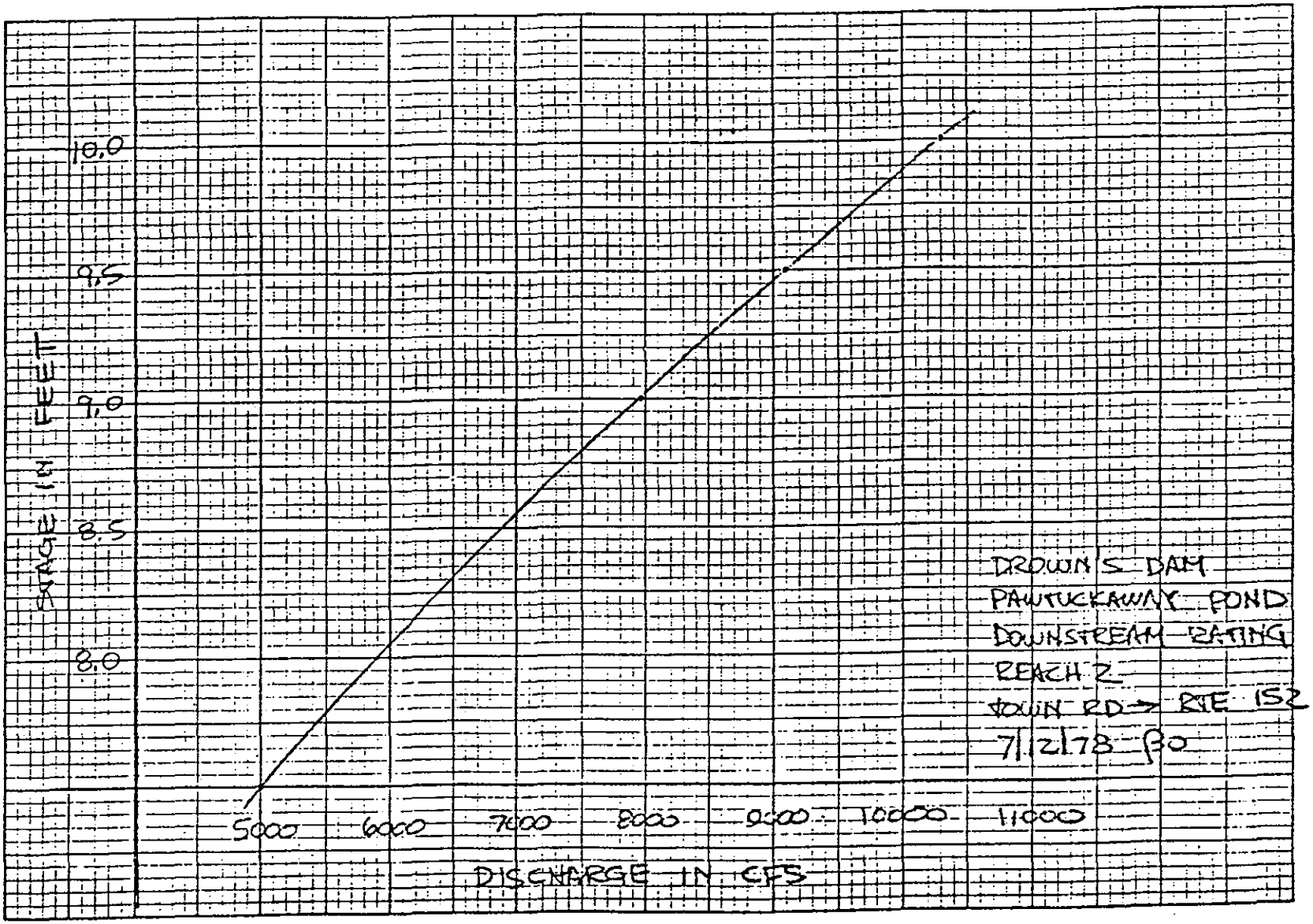
INFLOW INTO REACH = 5600 cfs

FROM D/S HAZARD REACH 2 RATING CURVE:

STAGE @ 5600 cfs = 7.85 FEET

REACH 2 LENGTH = 14000'

VOLUME WITHIN REACH = V_2


10.0
9.5
9.0
8.5
8.0
STAGE IN FEET
5000
6000
7000
8000
9000
10000
11000
DISCHARGE IN CFS
DROWNS DAM
PAWTUCKAWAY POND
DOWNSTREAM RATING
REACH 2
DOWN RD → RTE 152
7/12/78 BO

$V_2 = 14000 \times 4465 = 1435$ AF

since $V_2 < \frac{1}{2} S$ REACH ok

$Q_2 = Q_1 (1 - V_2/S)$

$= 5600 (1 - 1435/11700) = 4915$ cfs

STAGE @ 4915 cfs = 7.45 FEET

$V_3 = 14000 \times 4100 = 1320$ AF

AVE STORAGE = $(1435 + 1320)/2 = 1375$ AF

$Q_{FINAL} = Q_1 (1 - V_{AVE}/S)$

$= 5600 (1 - 1375/11700) = 4940$ cfs

@ Q = 4940 cfs
STAGE = 7.5 FEET
STOR = 1375 AF

WAVE INTO TOWN

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS